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n the temperature of optical uniaxiality in Gypsum.

By A. Hutchinson, M.A., Ph.D.
and A. E. H. Tutton, M.A., D.Sc., F.R.S.

[Read January 23, 1912.]

Introduction.

N the account of an investigation of the optical properties of gypsum published by one of us (A. E. H. T.) in 1908[1] it was stated, as the ult of direct measurement in sodium-light of the optic axial angle of section-plate perpendicular to the first median line, which was heated an air-bath, that the substance became uniaxial at 105·2° C. Three ier section-plates examined subsequently gave somewhat higher values, e results ranging from 109·5° to 114·2° C. These figures were arrived after a considerable correction, amounting to as much as 7°, had been plied for conduction along the crystal-holder, the temperatures actually served being greater by this amount.

Illumination of the plates with light of various colours established the eresting fact that the temperature of uniaxiality varied for different

[1] A. E. H. Tutton, 'The optical constants of gypsum at different temperatures, l the Mitscherlich experiment.' Proc. Roy. Soc. London, 1908, ser. A, . lxxxi, pp. 40–57; also with additions in Zeits. Kryst. Min., 1909, vol. xlvi, 135.

parts of the spectrum, and attained a maximum in the case of light of wave-length 573 as shown in the following table, where the temperatures given in column A were obtained in the case of a plate cut by Hilger, those in columns B, C, and D referring to plates supplied by Steeg and Reuter.

Wave-length.	A	B	C	D
671 (Li)	104·5°	108·0°	113·0°	110·0°
656 (H_α = C)	104·7	108·5	113·2	110·3
589 (Na = D)	105·2	109·5	114·2	111·3
573	105·5	110·0	114·5	111·5
535 (Tl)	105·1	109·0	114·0	111·0
486 (H_β = F)	104·5	108·0	113·0	110·0
431 (G)	102·5	106·0	111·0	108·0

It will be noticed, moreover, that the plates become uniaxial at the same temperature for wave-lengths 671 and 486, and this is also very approximately true for wave-lengths 589 and 535.

These results were, however, not in accord with those obtained by observations of the refracted images produced by the prism cut by Hilger for the determination of the α and β indices from the same crystal as the plate. On heating this prism the two images corresponding to the indices α and β approached one another, at 80° C. they were separated by 3′ only, and at 90° they appeared to coincide. Between 90° and 100° no change could be detected, but at 105° one image had passed the other and was separated from it to the extent of 2′. These observations indicate that the temperature at which gypsum becomes uniaxial lies between 90° and 100° C. and is certainly lower than 105°, though the change produced by a rise of temperature of two or three degrees was too small to allow of an accurate determination of the temperature of uniaxiality by this method.

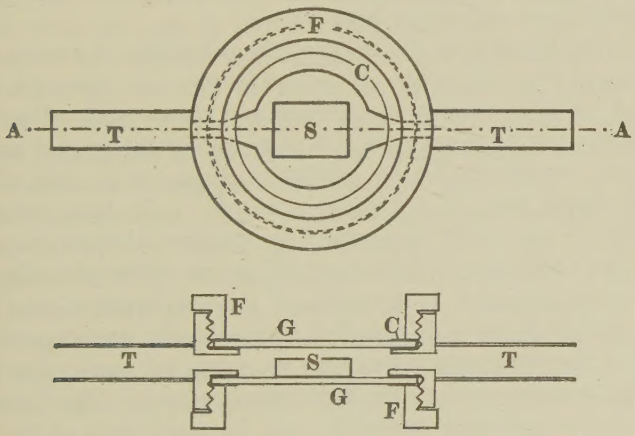
Here the matter rested till in July, 1911, Professor R. Brauns[1] pointed out that it is easy to demonstrate that gypsum becomes optically uniaxial at a temperature well short of 100° C. by simply warming a section on a water-bath and rapidly transferring it for observation to the stage of a polarizing microscope. This simple experiment proved conclusively that the figures published in 1908 were considerably too high, and it became a point of some interest to find as accurately as possible the

[1] R. Brauns, 'Die Aenderung des optischen Achsenwinkels in Gips bei höherer Temperatur.' Centralblatt Min., 1911, pp. 401–405.

emperature at which uniaxiality really occurs. Some experiments with his object were therefore undertaken by one of us (A. H.), and in verbal communication made to the Mineralogical Society in November, 911,[1] a temperature of 95° C. was mentioned as an approximate upper imit of the phenomenon. Subsequently some improvements were made n the apparatus, and the final result at which we have arrived is, that or sodium-light gypsum becomes uniaxial at 90·9° C.

Experimental Methods.

As the errors in the results obtained in 1908 appear to be due to the ype of air-bath employed, which afforded no security that the tempera- ure of the crystal-section was really that recorded by the thermometers, was decided to attempt to eliminate this source of uncertainty by



Figs. 1 and 2.—Hot-water cell for heating gypsum plate on stage of microscope.

mmersing the section-plate in a liquid. A small shallow circular brass ell, provided with a glass top and bottom, was therefore constructed and tted with two brass tubes, one on each side, to act as inlet and outlet r a stream of water saturated with calcium sulphate and heated to any quired temperature below 100°, which was conducted through the ell during the observations. The temperature of this water stream as taken immediately before entering and directly after leaving the ell by two thermometers graduated to $\frac{1}{5}$° C. The thermometers were nclosed in the glass tubes by which the hot solution was conducted to

[1] Mineralogical Magazine, vol. xvi, p. xxx; vide Nature, 1911, vol. lxxxviii, 105, where owing to a misprint the temperature is given as 25°.

and from the cell, and were therefore wholly immersed in the hot liquid. They were compared with the standards at the National Physical Laboratory, and the corrections found necessary duly applied.

The construction of the cell is indicated in the accompanying diagrams, fig. 1 being a plan, and fig. 2 a vertical section through the line *AA*, both full size. The top and bottom of the cell are formed by the glass plates *G*, which are held in position by the screw flanges *F*. Rings of thin cardboard below the glass keep the cell water-tight, and thin brass washers *C* protect the glass plates from the direct action of the screws. The hot liquid enters and leaves the cell by the tubes *TT*, to which horizontal glass tubes about 1 cm. in internal diameter are connected. These contain the thermometers, which are arranged with their bulbs as near the cell as possible. The section-plate of gypsum perpendicular to the first median line, seen at *S*, is held in position by a small spring (not shown) formed by a coil of thin brass wire.

The cell was adjusted on the stage of the polarizing microscope, and was insulated from the stage of the microscope and protected from radiation by suitable coatings of cardboard and cotton-wool. The tubes containing the thermometers were also protected for the greater part of their length. On allowing the hot calcium sulphate solution, kept stirred in a large copper tank, to run through the cell it was found that the temperature of uniaxiality, as measured by the thermometers immersed in the stream, could easily be kept steady for a time sufficiently prolonged for the changes produced by alteration of the wave-length of the illuminating light to be accurately studied. Occasionally the temperatures indicated by the two thermometers were the same, but usually that first reached by the stream read a little higher than the other. The difference did not, however, generally exceed $\frac{1}{2}^{\circ}$, and the mean value of the two readings was taken as giving the actual temperature of the section-plate in the cell.

This mode of experimenting possesses some disadvantages, one being the ultimate corrosion of the plate, but in its favour it may be urged that it is hard to conceive that the temperature of the plate can exceed that registered by the first thermometer or be lower than that recorded by the second, and moreover, as the thermometers are wholly immersed, no corrections of uncertain magnitude for the exposed portion of the stem are necessary.[1] As a matter of fact the results obtained on different days and with two different section-plates proved to be very concordant.

[1] If only the bulb and a small portion of the stem were immersed this correction would probably lie between 0·5 and 1·0° C.

The kind of accuracy attained can be estimated from the following series of successive observations of the point of uniaxiality in sodium-light:

Thermometer I,	90·6°	90·8°	90·6°	90·7°	90·6°	90·5°	90·4° C.
„ II,	90·0	90·3	90·3	90·2	90·1	90·0	90·0 C.

The mean result deduced from these observations is 90·36° C. On introducing the fixed-point corrections which have to be applied to the thermometers we arrive at the temperature 90·9°, the value we consider to be nearest the truth for sodium-light. Four sets of confirmatory observations made on different days, the first with the same section-plate as above, and the other three with a different one, gave the corrected values 90·8°, 90·4°, 90·9°, and 91·0° respectively.

The effect of altering the wave-length of the light employed was also studied, with the result that so far as their relative values are concerned the observations made in 1908 are fully confirmed. Thus it was found that when the temperature of uniaxiality had been reached for red, the crystal was also uniaxial for green, but still distinctly biaxial for intermediate colours. When, however, at a slightly higher temperature it became uniaxial for sodium-light it was noticed that the axes for red and blue had distinctly separated in a plane at right angles to that which they at first occupied. The corrected temperatures actually determined are as follows: in lithium-light, wave-length 671, the crystal becomes uniaxial at 90·2° C. In F-light, green, wave-length 486, at 90·1°, while the maximum temperature observed, 91·0°, corresponds to light of wave-length 570–575. The relations of these values for the different wave-lengths are so close to those shown in the table published in 1908 that the following undoubtedly represents a very close approximation to the truth:

Temperature of optical uniaxiality of gypsum for different wave-lengths.

Wave-length.	Temperature.
671 (Li)	90·2° C.
656 (H_α = C)	90·4
589 (Na = D)	90·9
573	91·0
535 (Tl)	90·8
486 (H_β = F)	90·1

In view of these results it was thought advisable to repeat the measurements of the indices of refraction by the prism method made

in 1908, and more especially to study anew the effect of gradually raising the temperature of the prism giving α and β. In the first place, the published values of α, β, and γ at 12° C. were absolutely confirmed. Secondly, it was found that on slowly heating the prism giving α and β the two images of the collimator-slit gradually approached one another. Using sodium-light their separate existence could still be detected at 89° C., but at 91° they coalesced completely. When, however, the temperature had risen to 93° two independent images could once more be recognized. The results obtained in 1908 as well as those just described are therefore amply confirmed. It was, moreover, thought desirable to make a complete set of refractive index determinations at a temperature a little lower than the highest previously employed, and in the table below the values observed at 98° are given, those already determined at 12° and at 105° being quoted for the sake of comparison.

Wave-length.	Index α.			Index β.			Index γ.		
	12°	98°	105°	12°	98°	105°	12°	98°	105° C.
Li	1·5178	1·5162	1·5154	1·5201	1·5166	1·5158	1·5270	1·5247	1·5243
C	1·5184	1·5168	1·5160	1·5207	1·5172	1·5164	1·5276	1·5253	1·5249
Na	1·5207	1·5193	1·5184	1·5230	1·5196	1·5188	1·5299	1·5277	1·5274
573	1·5213	1·5199	1·5190	1·5237	1·5201	1·5194	1·5307	1·5284	1·5280
Tl	1·5231	1·5219	1·5209	1·5255	1·5222	1·5213	1·5325	1·5304	1·5300
F	1·5262	1·5248	1·5239	1·5285	1·5252	1·5243	1·5355	1·5332	1·5330
G	1·5303	1·5294	1·5285	1·5328	1·5299	1·5289	1·5400	1·5379	1·5377

The α and β indices interchange vibration-directions at about 91° C. the vibration-direction for γ remains for all temperatures that of the first median line lying in the symmetry-plane. A comparison of the values of α and β determined at 98° C. shows that the minimum difference, 0·0002, is attained for light of wave-length 573, while equal differences, 0·0003, are observed in the case of sodium- and thallium-light, and still greater, but also equal differences, 0·0004, are found for lithium- and for F-light.

Conclusions.

The results we have obtained lead us to conclude:

1. That gypsum becomes optically uniaxial in sodium-light at 90·9° C. The point of uniaxiality is reached at the slightly lower temperatures of 90·2° for lithium-light and 90·1° for F-light, while a slightly higher temperature 91·0°, the maximum, is required to produce the uniaxial figure when the crystal-section is examined in light of wave-length 573

2. That the temperature determinations made in 1908, although considerably too high, are relatively correct among themselves.

3. That the refractive index determinations already published are quite accurate, and both these and the additional values now given agree completely with the conclusions stated in 1 and 2 above.

Since a notice of this work first appeared in 'Nature', Professor E. H. Kraus, of the University of Michigan, has very courteously informed us by letter that he has been occupied with the same problem, and has determined the temperature of uniaxiality in sodium-light as 89·67° C. in the case of a section-plate heated in an oil-bath, while for a section heated in an air-bath the somewhat higher value 91·6° C. was obtained.[1] It is interesting to notice that the temperature was originally given by Mitscherlich as about 73·5° R., which corresponds to 91·9° C.

[1] This work has since been published in detail: E. H. Kraus and L. J. Youngs, 'Über die Änderungen des optischen Achsenwinkels in Gips mit der Temperatur.' Neues Jahrbuch Min., 1912, vol. i, pp. 123–146. It does not appear from the description what correction, if any, was applied for the exposed portions of the stems of the long thermometers employed; and in reply to an inquiry, Professor Kraus has very courteously informed us that, as a matter of fact, no such correction was applied. He believes, however, that under the conditions of the experiments this correction could not in any case have exceeded 0·7° C.

On Sericite from North Wales and on Penninite and Labradorite from Ireland.

By A. Hutchinson, M.A., Ph.D.
and W. Campbell Smith, B.A., F.G.S.

[Read November 17, 1908, and November 12, 1912.]

FOR the first of the three minerals to be described in the following pages we are indebted to Mr. W. G. Fearnsides, who collected it in North Wales in the autumn of 1908, and we desire to express our best thanks to him for the readiness with which he placed at our disposal enough suitable material for a complete analysis. The other two minerals were collected by ourselves.

1. Sericite from North Wales.

This mineral occurs in an old road-metal quarry, one mile west of Tan-y-Bwlch, Merioneth, North Wales. It is found in open joints and veins in quartz strings which transgress a dolerite sill and extend into the country-rock, a hard member of the Lingula Flags. The mineral forms irregular talc-like aggregates readily cleaving into very small plates. The colour is pale green, thin flakes being almost colourless.

The specific gravity was found by suspension in a heavy liquid to be 2·798, as compared with water at 4° C. Two refractive indices, β and γ, measured by Schroeder van der Kolk's method on cleavage fragments, were found to be 1·589 and 1·594 respectively. Cleavage flakes show a biaxial interference-figure, the acute bisectrix being normal to the cleavage. The sign of the double refraction is negative. Dispersion weak, $\rho > v$. The angle 2E between the optic axes in air was found by measuring the distance between the optic eyes by means of a micrometer eye-piece provided with a travelling cross-wire. A value for E was then obtained by Mallard's formula $D = K \sin E$, the value of K for the microscope being determined by the aid of minerals of known optic axial angle, near to that of the sericite. The mean of several determinations gave $2E = 68° 50'$ for sodium-light. A percussion-figure was obtained in which the leading-ray was at right angles to the plane of the optic axes.

Great care was taken in selecting material for analysis, and under the microscope it was seen to be free from quartz and to contain no inclusions. Total water was determined on about one gram of the fine powder by strong ignition in a current of dry air, the platinum boat containing the sample being placed in a tube of silica glass which was enclosed in a furnace made from a plumbago crucible and heated over a powerful Colast. The water was absorbed in a weighed U-tube containing concentrated sulphuric acid. After the total water had been determined, the powder was fused with sodium carbonate and the other constituents estimated by the methods described by Hillebrand and Washington. Alkalis were determined on 0·8 gram by the method of Lawrence Smith. Samples of 0·5 gram were used for the estimation of ferrous iron, while hygroscopic water was determined by heating one gram of the powdered mineral in a toluene bath.

The results of two concordant analyses are given in columns I and II of the table below. Column III gives the mean of these, column IV the corresponding ratios, while in columns V and VI are quoted for comparison analyses by Fraatz[1] of a sericite from Werlau, and by S. Blau[2] of a muscovite from Bengal; a very similar analysis to the last has been published by L. Sipöcz.[3]

	I.	II.	III.	IV.	V.	VI.
SiO_2	46·50	46·51	46·51	0·7702	45·58	45·57
Al_2O_3	36·63	36·52	36·58	0·3580	36·76	36·72
Fe_2O_3	0·54	0·48	0·51	0·0032	1·13	0·95
FeO	0·49	0·46	0·48	0·0067	—	1·28
CaO	0·42	0·46	0·44	0·0078	—	0·21
MgO	0·44	0·48	0·46	0·0114	0·85	0·38
K_2O	7·79	7·89	7·84	0·0831	9·29	8·81
Na_2O	1·71	1·84	1·77	0·0283	1·36	0·62
H_2O+	4·92	5·14	5·03	0·2793	5·16	5·05
H_2O (105°)	0·11	0·11	0·11	—		
F	—	—	—	—	—	0·15
Li_2O	—	—	—	—	—	0·19
Total	99·55	99·89	99·73	—	100·13	99·93
Sp. gr.	—	—	2·798	—	2·875	2·831

The results given above show that silicon and oxygen are present in

[1] A. Groddeck, Neues Jahrb. Min., 1883, Beil.-Band ii, p. 90.
[2] S. Blau, Tschermak's Min. Mitt., 1873, p. 32.
[3] L. Sipöcz, ibid., 1878, p. 31.

almost exact orthosilicate ratios, the mineral conforming closely to type 1 of Clarke's formulae,[1] viz.:

$$\begin{array}{r} \diagup\ SiO_4 \equiv R_3 \\ Al - SiO_4 \equiv Al \\ \diagdown\ SiO_4 \equiv Al \end{array}$$

It can be represented as a combination of this type with small quantities of types 3 and 4.

2. Penninite from Recess, County Galway, Ireland.

This mineral occurs in veins and joints in the ophicalcite, the so-called 'Connemara marble', which is quarried at Recess, County Galway.

It forms hexagonal plates which are sometimes 1 cm. across. These plates are flexible but not elastic, they possess a perfect basal cleavage, and are transparent and colourless to pale brown. The specific gravity is 2·619 as compared with water at 4° C. The double refraction is weak and the optical properties often vary even in the same plate, for though usually optically positive and sensibly uniaxial, plates are found which exhibit biaxial portions, while other plates again are negative in character. The plates give a percussion-figure whose leading-ray is parallel to the optic-axial plane in the biaxial portions. A determination of the index of refraction for sodium-light by a total reflection method gave a value of 1·551.

When heated before the blowpipe the mineral glowed strongly, remained white, and did not swell up. It was just fusible when in thin flakes.

Carefully selected material was used for the analyses, which were carried out by the methods described above. Fluorine and lithium were tested for but proved to be absent. The precipitates of aluminium hydroxide and of magnesium ammonium phosphate were purified by three precipitations. The results of the analyses are given in columns I and II, the mean of these in III, and the ratios in columns IV and V.

	I.	II.	III.	IV.	V.
SiO_2	34·85	34·78	34·81	0·5763	0·5763
Al_2O_3	16·43	16·00	16·21	0·1586	0·1654
Fe_2O_3	1·05	1·13	1·09	0·0068	
FeO	0·36	—	0·36	0·0050	0·7630
CaO	0·95	0·55	0·75	0·0134	
MgO	30·03	30·07	30·05	0·7446	
K_2O	1·71	1·99	1·85	0·0196	0·7251
H_2O+	12·70	12·72	12·71	0·7055	
H_2O (105°)	1·82	1·97	1·89	0·1051	
			99·72		

[1] F. W. Clarke, Amer. Journ Sci., 1889, ser. 3, vol. xxxviii, p. 385.

It does not appear possible to deduce any satisfactory formula from these numbers, but if the water driven off below 105° is omitted and Fe_2O_3, FeO, CaO, and K_2O are replaced by equivalent quantities of Al_2O_3, MgO, and H_2O respectively, then the empirical composition of the substance is approximately represented by the formula $H_{23}Mg_{12}Al_5Si_9O_{49}$.

On comparing the composition of this mineral with that of other members of the chlorite group, it will be seen that it presents the greatest analogy to a compact variety of penninite called pseudophite,[1] from which, however, it differs in that it occurs in fairly developed crystals.

3. Labradorite from County Down, Ireland.

Among the many dykes intruded in the slates and exposed along the shore of County Down two in particular long ago attracted attention on account of the extraordinary size of their felspar phenocrysts, which are often 5 to 6 cm. long and 3 to 4 cm. wide, and sometimes attain much greater dimensions. These dykes occur just below the lighthouse at St. John's Point near Ardglass, and were briefly described by Traill and Egan[2] in 1871. They vary in width from four to six feet, and it is in their wider parts that the porphyritic habit is best developed.

The phenocrysts are set in a black, very compact groundmass, in which a few round patches of black glass, about 1 mm. in diameter, are the only constituents which can be made out with the naked eye. Under the microscope this groundmass is seen to consist very largely of short laths of plagioclase felspar showing albite-twinning. These give a maximum extinction angle of 30°, corresponding to labradorite. The interstices between the felspars are filled up by augite, magnetite, and green glass. The augite occurs, not as granules, but as groups of closely packed and strictly parallel straight rods of a pale violet colour bordered by minute cubes of magnetite. There is no apparent relation between the orientation of these rods in the separate groups. Similar growths of augite and magnetite have been observed in many basic rocks, some peculiar forms

[1] Compare analyses by: R. v. Drasche, Tschermak's Min. Mitt., 1873, p. 126; W. Gintl, ibid., 1874, p. 7; K. v. Hauer, Sitz.-Ber. Akad. Wien, 1855, vol. xvi, p. 170; V. Wartha, Zeits. Kryst. Min., 1887, vol. xiii, p. 72; P. von Groth, ibid., 1877, vol. i, p. 509; E. Cohen, ibid., 1888, vol. xiv, p. 409; M. F. Heddle, Mineralogical Magazine, 1880, vol. iii, p. 138; H. Fox, ibid., 1892, vol. ix, p. 275.

[2] W. A. Traill and F. W. Egan, Mem. Geol. Surv. Ireland, 1871, sheets 49, 50, and part of 61, p. 58.

having been described recently by Bailey [1] from Argyllshire and by Prior [2] from Natal. In the present case, however, none of these complex branching growths occur, only simple straight rods being observed. The round patches of glass mentioned above are very irregularly distributed, two or three often occurring close together. They consist of a dark brown or green, almost opaque glass showing incipient devitrification. They no doubt represent segregations of the glassy residue left after the separation of the crystalline constituents.

The phenocrysts of plagioclase all show albite-twinning frequently combined with Carlsbad-twinning. Zonary banding is almost entirely absent, but near the borders there are often lines of very small inclusions of augite and magnetite which follow the outline of the crystal. The crystals occasionally contain irregular patches of the groundmass, and sometimes present rounded edges. On the whole, however, the felspar of the phenocrysts is seen to be of a high degree of purity, and therefore affords excellent material for optical and chemical investigation.

In the hand-specimens the phenocrysts are of a greenish-yellow tinge. They are invariably tabular parallel to $b(010)$, and are terminated by faces which are probably $c(001)$ and $x(\bar{1}01)$. The cleavages parallel to $c(001)$ and $b(010)$ are both perfect, and give faces which afford good reflections on the goniometer. The angle (001) : (010) is 85° 57′. On twinned fragments the angle between the two c cleavages was found to be 8° 8′, corresponding to 85° 56′ for (001) : (010).

The extinction-angles measured on cleavage fragments are:

On $c(001)$, −11° to the trace of the b cleavage.
On $b(010)$, −23° „ „ „ c „

Two plates were cut as nearly as possible parallel to $b(010)$, and these were carefully polished on one face. The position of the polished face was verified by measurements on to the cleavages $c(001)$ and $m(110)$. On examination in convergent light it was found that one optic axis emerged just outside the field of view.

The refractive indices were measured on these two plates by means of an Abbe-Pulfrich total-reflectometer. In each case the glass hemisphere of the refractometer was rotated through 360°, readings being taken at intervals of 10° with the telescope first on one side and then on the other. Both limits of total reflection pass through a maximum and a minimum, which were determined as accurately as possible. The positions of these maxima and minima give four angles θ_γ, θ_β, θ_α, and

[1] E. B. Bailey, Trans. Edinburgh Geol. Soc., 1904, vol. viii, p. 366.
[2] G. T. Prior, Annals Natal Museum, 1910, vol. ii, p. 146.

.. Three of these are the critical angles corresponding to the principal dices: the angle to be rejected θ_n is that maximum or minimum for hich the vibration-direction is in the plane of incidence.[1]

The critical angles obtained from the two plates using sodium-light ere:

	Plate I.	Plate II.
θ_γ ...	56° 15′·25	.... 56° 15′·5
θ_β ...	55 58·25	... 55 59·75
θ_α ...	55 46·25	... 55 46·75

Each of these values represents the mean of four readings. The fractive index of the glass hemisphere of the refractometer was found measuring the critical angles for glasses of known refractive indices, ar those of the felspar.

The values thus obtained for the refractive indices are:

$$\alpha = 1{\cdot}5630, \quad \beta = 1{\cdot}5665, \quad \gamma = 1{\cdot}5712.$$

The calculated value for 2V obtained from these figures is 81° 48′, the lspar being optically positive.

The material used for analysis was very carefully selected, and consted of small water-clear cleavage fragments in which no trace of clusions could be perceived with a lens, though it is probable that the on found was derived from small specks of magnetite or thin incrustaons of hydrated oxide which had escaped notice. The mean specific avity of the mineral analysed was 2·706, compared with water at 4° C. ne determination was made by the suspension method in a mixture of romoform and xylol. Particles of density greater than 2·71 or less than 70 were rejected.

The analyses were made on quantities of from 0·5 to 1·0 gram in the ineralogical Laboratory of the University of Cambridge, I and II by r. G. G. Knighton, III by Mr. M. C. Burkitt, and to these gentlemen e desire to express our thanks for the care they gave to their execution. olumn IV of the table below gives the mean of the three analyses, the termination of alumina of analysis III being, however, omitted as robably too low; column V the percentage composition of the felspar, the assumption that the water lost on ignition and the ferric oxide und are adventitious constituents. Column VI gives the ratios obtained hen the percentages of column V are divided by the molecular weights the oxides.

[1] C. Viola, Zeits. Kryst. Min., 1902, vol. xxxvi, p. 245.

	I.	II.	III.	IV.	V.	VI.	VII.
SiO_2	52·22	52·32	52·44	52·33	52·57	0·8704	52·48
Al_2O_3	30·34	30·10	(29·93)	30·22	30·36	0·2971	30·22
Fe_2O_3	0·42	0·39	—	0·40	—	—	—
CaO	12·37	12·79	12·39	12·52	12·58	0·2242	12·70
K_2O	0·70	0·79	1·07	0·85	0·85	0·0090	0·85
Na_2O	3·92	3·57	3·36	3·62	3·64	0·0586	3·74
Ign. loss	—	—	0·36	0·36	—	—	—
				100·30	100·00		

Now in anorthite lime, alumina, and silica are in the ratio 1 : 1 : 2, while in albite and orthoclase the ratios of alkalis, alumina, and silica are as 1 : 1 : 6. If then we take the ratios of column VI and remove anorthite, we find that the alkalis are to the residual alumina and silica as 0·0676 : 0·0729 : 0·4220, instead of in the ratio 0·0703 : 0·0703 : 0·4220, the values which should be obtained if the residual silica were entirely present as albite or orthoclase.

The above results lead to the conclusion that this felspar can be represented as $33NaAlSi_3O_8.5KAlSi_3O_8.62CaAl_2Si_2O_8$. The theoretical percentages for a felspar of this formula are given in column VII and exhibit a good agreement with the observed values.

It is interesting to notice that two somewhat similar felspars have been recently described, one by Ford and Bradley,[1] the other by Bonillas.[2] The first specimen occurred in rolled fragments and came from the Altar Mountains, Mexico, the second from the basalts of Pinacate, Altar district, Sonora. The compositions of these minerals are as follows, the figures given for the specimen from the Altar Mountains, A, being the mean of two concordant analyses; B is the mineral from Pinacate.

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	CaO.	MgO.	K_2O.	Na_2O.	Ign.
A.	51·24	30·84	0·73	—	13·59	—	0·17	3·76	0·24
B.	50·58	29·43	2·71	0·34	12·62	0·31	0·50	3·17	0·35

For the sake of comparison with one another, and with the theoretical composition of mixtures of albite and anorthite, our analysis and the two above quoted have been calculated to 100, potash being supposed to be replaced in each case by an equivalent amount of soda. The results are tabulated below, the composition and physical properties of the felspars

[1] W. E. Ford and W. M. Bradley, Amer. Journ. Sci., 1910, ser. 4, vol. xxx, p. 151. Here 'Altar' is printed incorrectly as 'Altai'.

[2] Y. S. Bonillas, Parergones Instit. Geol. Mexico, 1910, vol. iii, p. 427. As pointed out by Bonillas (p. 432), these two descriptions probably refer to the same occurrence.

rom Ireland, the Altar Mountains, and from Pinacate being given under , II, and III respectively; while under I a, II a, and III a are to be ound the calculated data for felspars of the compositions 38 Ab 62 An, 4 Ab 66 An, and 32 Ab 68 An.

	I.	II.	III.	I a.	II a.	III a.
SiO_2	52·73	51·47	51·37	52·63	51·63	51·13
Al_2O_3	30·44	30·98	31·63	30·31	30·98	31·32
CaO	12·62	13·66	13·46	12·74	13·52	13·92
Na_2O	4·21	3·89	3·54	4·32	3·86	3·62
Sp. gr.	2·706	2·718	2·731	2·704	2·711	2·714
Ext. on *c*	−11°	−12° 13′	−12° 40′	−10·3°	−12·5°	−13·8°
Ext. on *b*	−23°	−24° 37′	−26° 3′	−23·7°	−25·5°	−26·5°
a	1·5630	—	—	1·5630	—	—
β	1·5665	—	—	1·5667	—	—
γ	1·5712	—	—	1·5715	—	—

The calculated specific gravities given above are based on the values ·605 and 2·765 assigned by Day and Allen to albite and anorthite espectively. If the values 2·624 and 2·758 adopted by Wülfing are ade the basis of calculation, slightly higher values, 2·707, 2·7125, and ·715 are obtained. The other results, quoted for comparison, are taken om the charts given in 'Rock Minerals' by J. P. Iddings, 2nd edit., 911, p. 223; and in 'Elements of Optical Mineralogy' by N. H. and . N. Winchell, 1909, p. 200.

It will be seen that the felspar from St. John's Point is a basic bradorite, and that its physical properties are quite in accord with e place in the plagioclase series to which it must be assigned on account its chemical composition.

Note.—In the abstract which appeared in 'Nature', 1912, vol. xc, p. 375, the dices of this felspar were erroneously given as $\alpha = 1.5598$, $\beta = 1.5648$ and = 1.5694. The correct values now published are the result of two highly ncordant series of observations made, one with an Abbe-Pulfrich reflectometer described above, the other with a Kohlrausch total-reflectometer provided ith an attachment for rotating the plate in its own plane when immersed in omonaphthalene.

Notes on the occurrence of Dundasite in Derbyshire and Co. Galway.

By Arthur Russell.

[Read March 21, 1911.]

An occurrence of the rare mineral dundasite (hydrous carbonate of lead and aluminium) at the Welsh Foxdale mine, Trefriw, Carnarvonshire, was described by Dr. G. T. Prior in 1906.[1] Since then the mineral has been found by the writer at two additional localities in the United Kingdom. Certain specimens collected in 1910 at the well-known Mill Close mine, Wensley, Derbyshire, show a mineral which examination has proved to be dundasite. It occurs here as minute white or yellow spheres, not exceeding $\frac{3}{4}$ mm. in diameter, the exterior smooth and waxy, the interior radiating and silky. The spheres are implanted on small colourless cubes of fluor, or sprinkled over the surface of a dense grey chert, and are associated with small colourless twinned crystals of cerussite, indistinctly crystallized brown calamine ($ZnCO_3$), small black crystals of blende, and galena. A bright canary-yellow crust of greenockite coats all these minerals, making the specimens conspicuous. The specific gravity, optical and chemical characters, agree closely with those of the dundasite from the Welsh Foxdale mine. The mineral is decomposed by strong sulphuric acid with the liberation of carbon dioxide. The presence of aluminium was detected by the microchemical reaction with caesium-alum.

The occurrence of good specimens of the earthy variety of greenockite is interesting, the only other locality in the British Isles where the mineral occurs in this form being the Wanlockhead mines, Dumfriesshire. There is a specimen from here in the British Museum (Natural History), presented by Patrick Dudgeon in 1886, showing greenockite associated with blende and hemimorphite. At the other British locality, namely, Bishopton tunnel, Erskine, Renfrewshire, the mineral is invariably crystallized.

Mill Close mine is worked for lead and zinc, the vein lying between

[1] G. T. Prior, 'Dundasite from North Wales.' Mineralogical Magazine, 1906, vol. xiv, pp. 167–169.

limestone-shale and dolerite (toadstone). At the present time it is by far the most productive, besides being one of the oldest mines in Derbyshire. In addition to those already mentioned, the following minerals occur there:[1] Galena occasionally as cubes 2 inches along the side; marcasite as large balls with a bright platy exterior; calcite as scalenohedra occasionally measuring a foot along the vertical axis; fluor as colourless or slightly yellowish cubes, often showing included layers of marcasite; barytes in coral-like form of a white or brown colour (locally known as 'brain-stone') composed of small elongated wedge-shaped crystals.

During the summer of 1908 I visited the then newly opened Clements Head mine, which is situated on a westerly arm of Lough Corrib in the townland of Carrowgarriff, near Maam, Co. Galway. Mining was then being carried on by means of an open-cut on a rich north and south lead lode traversing slaty rocks. With the exception of a few specimens of dundasite here described, there was little of interest to the mineralogist.

The dundasite here occurs in two distinct forms. Usually as minute snow-white silky balls or flattened spheres, which are sprinkled over a mass of silky black slate, and are associated with a little acicular cerussite, allophane, quartz, pyrite, and limonite. Under the microscope the balls are seen to be either smooth on the exterior or to consist of divergent needles. In the other and rarer variety the dundasite forms snow-white loosely aggregated needles (resembling fine down) occupying cavities in a vein-stuff consisting of quartz, galena, blende, calcite, and silky slate, associated with which are a few small crystals of pyrite and acicular cerussite. The specific gravity of the balls was found to be about 3·25; both varieties agree in chemical and optical characters with the species dundasite. The association with allophane and cerussite recalls the occurrence at the Welsh Foxdale mine, Carnarvonshire. The allophane forms small glassy spherules, either white, or brown from admixed limonite; its specific gravity is about 1·87.

[1] C. E. Parsons, 'The deposit at the Mill Close lead mine, Darley Dale, Matlock.' Trans. Fed. Inst. Mining Engineers, 1896, vol. xii, p. 115.

The meteoric stones of El Nakhla El Baharia (Egypt).[1]

(*With Plates IX and X.*)

By G. T. Prior, M.A., D.Sc., F.R.S.
Keeper of Minerals in the British Museum.

[Read November 14, 1911, and June 18, 1912.]

Fall of the Stones.

ACCORDING to the accounts which have been published by members of the Egyptian Geological Survey,[2] a number of meteoric stones fell to earth on June 28, 1911, at about 9 in the morning, in the hamlets[3] to the west and north of the village of El Nakhla El Baharia (31° 19′ N., 30° 21′ E.) in the district of Abu Hommos, about twenty-four miles east of Alexandria, Egypt.

The stones, in number about forty and in weight nearly 10 kilograms, fell over an area about 4½ kilometres in diameter, and were derived apparently from the explosion of a single large meteorite which, according to the evidence of many eye-witnesses, approached from the north-west along a track marked by a column of white smoke and inclined to the horizontal about 30°. Several explosions were heard, and the stones buried themselves in the ground to depths of from 10 to 30 cm., leaving holes inclined to the vertical.

Many of the stones were completely coated with a very brilliant, black, fused crust, while others were only partially covered. The weight of the individual stones varied from 1,813 grams to 20 grams.

Through the kindness of Dr. W. F. Hume, Director of the Geological Survey of Egypt, two fragments of stones of this, the first Egyptian meteorite, weighing respectively 725 and 274 grams, have been presented

[1] Communicated by permission of the Trustees of the British Museum.

[2] W. F. Hume, 'The first meteorite record in Egypt.' Cairo Scientific Journal, 1911, vol. v, no. 59, pp. 212–215. J. Ball, 'The meteorite of El Nakhla El Baharia.' Survey Department (Egypt), 1912, Paper no. 25, pp. 1–20, with three plates.

Descriptions of the meteorite have also been published by S. Meunier, Compt. Rend. Acad. Sci. Paris, 1911, vol. cliii, pp. 524, 785; and by F. Berwerth Min. Petr. Mitt. (Tschermak), 1912, vol. xxxi, p. 107.

[3] The hamlets near which stones were seen to fall are Ezbet Abdalla Zeid Ezbet Abdel Malek, Ezbet el Askar, and Ezbet Saber Mahdi.

to the British Museum by the Egyptian Government. The smaller of the two specimens is part of a stone which fell in a cotton-field about 200 metres north-east of the village of Abdel Malek. From this specimen has been taken the material for the present investigation.

External Characters.

The larger of the two specimens has roughly eight sides, two of which present a fresh fracture, finely crystalline and of a greenish-grey colour, while the rest are coated with a thin, black, varnish-like, fused crust, as glossy as that of the Sherghotty and Juvinas meteorites.

Except for one or two broad 'thumb-marks', three of the coated sides (two are seen on the right in Pl. IX, fig. 1) are fairly flat and smooth, and are probably primary faces: on them the fused surface shows under the lens a fine network of ridges with minute pittings in the intervening spaces. The four other coated sides (on the left in Pl. IX, fig. 1) are rough and uneven, and are probably secondary faces: the fused surface on these is much more glossy, with ridges wider apart and not forming such a regular network as on the smooth surfaces. On the smaller specimen, some of the surfaces show a partial fusion, sufficient only to form a few ridges of black, fused material, with interspaces still crystalline.[1]

Mineral Composition.

Under the lens the stone is seen to consist mainly of a medium-grained crystalline aggregate of two minerals, a green pyroxene, and, in smaller amount but larger grains, a reddish-brown olivine.[2]

No metallic iron or chondrules are visible, and the few grains attractable by a magnet from the powdered stone consist only of magnetite. The material is very friable and can be reduced to a coarse powder simply by rubbing between the finger and thumb.

Examined in thin sections under the microscope (Pl. IX, fig. 2) the material appears at first to consist simply of a holocrystalline aggregate of diopside and olivine, the diopside for the most part in fairly well-defined prismatic crystals, and the olivine in larger irregular grains showing no sharp outlines of crystal-faces. On closer investigation of

[1] See J. Ball, loc. cit., p. 4.

[2] The descriptions hitherto published of the meteorite contain varying statements of its mineral composition. In one, three-quarters of the stone is considered to consist of augite and the rest of hypersthene; in another, over 80 per cent. of the stone is regarded as hypersthene. That there is no reason, however, to doubt the general uniformity in character of the different stones of the fall is clear from the descriptions themselves, and from the chemical analyses which have been made of the stones (see p. 279).

the slides, however, between the main constituents can be detected in many parts interstitial material which, with a high power, resolves itself into a crystalline aggregate of felspar-laths with grains of augite and magnetite, like the matrix of a fine-grained basalt (Pl. X, fig. 1).

The felspar may be referred to oligoclase-andesine as it shows twin-lamellae, in one case giving symmetrical extinctions of about 20°, and has refractions slightly higher than that of the Canada-balsam.

Besides the felspathic interstitial material, F. Berwerth [1] describes also a grey interstitial breccia consisting mainly of augite and showing occasionally minute bronzite chondrules. This could not be detected in the particular slides examined, but enclosed in some of the olivines were seen minute perfectly spherical grains of pyroxene, often surrounded by a fringe of magnetite (Pl. IX, fig. 2, in the olivine at the top of the slide on the right) : in some cases the rounded grain consisted of a single individual of pyroxene, but occasionally it appeared to be of composite character suggestive of a chondrule.

Diopside.

The green pyroxene (diopside), comprising about three-quarters by weight of the stone, is nearly colourless in thin section, and, although without very sharply defined crystal-outline, generally shows prismatic sections, mostly about 1 mm. in length and 0·3 to 0·5 mm. in breadth.

Twinning on the orthopinacoid (100) is very common and is often repeated in the same individual ; many of these twins also exhibit the well-known 'herring-bone' structure due to repeated twinning on the basal plane (001) (Pl. IX, fig. 2 at the bottom on the right). In twins of this kind giving symmetrical extinction about the line of junction, the extinction ($c : c$) is about 40° to 44°, and the angle between the lamellae twinned on (001) and the same line 74° to 76°.

In an uncovered slide, a few sections twinned on (100) were found to be cut so that one half of the twin showed the emergence of an acute positive bisectrix. Measurements of the optic axial angle with an eye-piece micrometer gave 2E = 80°–87° (corresponding to 2V = 44°–48°). The double refraction in this half of the twin was low (about 0·005), whereas in the other half it amounted to about 0·030. Measurements of refraction in such sections by the Becke method, combined with determinations of the double refraction by means of a quartz-wedge, gave the following numbers as rough approximations of the refractive indices :

$$\alpha = 1{\cdot}685,\ \beta = 1{\cdot}69,\ \gamma = 1{\cdot}72.$$

[1] F. Berwerth, loc. cit., p. 110.

The chemical composition of the diopside, as calculated from the results of the bulk-analysis of the stone (p. 279) and of the analysis of the olivine (p. 278), is as follows:

SiO_2	...	...	52·73
FeO	...	...	14·93
CaO	...	...	19·22
MgO	...	...	13·12
			100·00
Specific gravity [1]		...	3·42

The numbers correspond approximately to a formula $3MgSiO_3 . 3CaSiO_3 . 2FeSiO_3$, which may be written $2MgCa(SiO_3)_2 . CaFe(SiO_3)_2 . MgFe(SiO_3)_2$, as representing a combination of diopside, hedenbergite, and bronzite molecules.

Olivine.

The brown olivine, the other principal constituent of the meteorite, is closely related to hortonolite and is much more ferriferous than any olivine previously described in meteorites.[2]

In weight it amounts to about 13–15 per cent. of the stone, but it occurs in larger and more irregular grains (up to 2 mm. across) than the diopside. In thin sections under the microscope a very slight pleochroism from colourless (for vibrations parallel to *b*) to very pale brown (for vibrations parallel to *c*) can sometimes be detected.

It appears to be of later consolidation than the augite, for it is often embayed by augite prisms and occasionally contains included grains of augite.

A characteristic feature is the presence of dark-brown to black inclusions. In sections cut at right angles to an obtuse positive bisectrix these inclusions appear as lenticular plates with their long axes directed parallel to the line joining the optic axes. Such sections, which are parallel to the orthopinacoid (100), generally show the traces of the fairly well-marked brachypinacoidal cleavage at right angles to the long axis of the inclusions (Pl. X, fig. 2). In sections cut at right angles to the acute negative bisectrix the inclusions appear only as short, sharply defined, black lines, all directed at right angles to the line joining the

[1] As determined on 1·0610 gram of the portion of the meteorite insoluble in hydrochloric acid (see p. 280).

[2] The Ensisheim meteoric stone, according to an analysis of the soluble portion by F. Crook (Inaug.-Diss., Göttingen, 1868, p. 22), is supposed to have 50 per cent. of olivine containing as much as 53 per cent. of FeO. In an uncovered slide of this stone in the Museum Collection the olivine, however, presents no unusual character, is quite colourless, and has refractions not higher than that of methylene iodide.

optic axes (Pl. X, fig. 3). Such sections, which are parallel to the brachypinacoid (010), generally show no well-marked cleavage. The inclusions appear, therefore, to be lenticular plates arranged with their flat surfaces parallel to the orthopinacoid (100) and their long axes parallel to *b* and their short axes to *c*. Under a high power the apparent plates resolve themselves into radiating black rods, and are probably skeletal crystals of magnetite or ilmenite (Pl. X, fig. 4).

Measurement of the optic axial angle of the olivine by means of an eye-piece micrometer gave $2E = 160°$ (corresponding to $2V = 67°$). From measurement of the refraction by the Becke method, and of the double refraction by the quartz-wedge in sections cut at right angles to the two bisectrices, the following numbers as rough approximations of the refractive indices were obtained:

$$\alpha = 1{\cdot}75,\ \beta = 1{\cdot}785,\ \gamma = 1{\cdot}80.$$

A chemical analysis was made of the olivine on grains picked out under the lens from the coarsely powdered stone. The material, weighing 0·2048 grams, was digested in hydrochloric acid (sp. gr. 1·06) and the small amount (0·0340 gram) of insoluble residue was treated in the usual way with sodium carbonate solution to remove silica, &c. The result of the analysis of the soluble portion is given under I. Under II and III are given for comparison analyses of hortonolite and fayalite respectively.

	I. (Olivine of El Nakhla.)	II. (Hortonolite.[1])	III. (Fayalite.[2])
SiO_2 ...	32·59	33·59	32·41
FeO ...	51·80 [3]	44·37	65·49
MnO ...	—	4·35	—
CaO ...	1·11	—	2·10
MgO ...	15·60 [4]	16·68	—
	101·10	98·99	100·00
Specific gravity	3·98 [5]	4·038	4·318

[1] G. J. Brush, Amer. Journ. Sci., 1869, vol. xlviii, p. 17.

[2] F. A. Gooch, Amer. Journ. Sci., 1885, vol. xxx, p. 58.

[3] The whole of the iron is here reckoned as FeO: the result of the bulk-analysis (p. 279) showed that the amount of Fe_2O_3 in the meteorite is small.

[4] The excess of 1 per cent. in the analysis is probably mainly due to excess of magnesia. The chemical composition of the olivine is better represented by the analysis of the soluble part of the meteorite which was made on a larger amount of material (see p. 280).

[5] Calculated from the specific gravity of the grains (3·842) and that of the portion of the meteorite insoluble in hydrochloric acid (3·415).

The chemical composition corresponds fairly closely to the formula $Fe_2SiO_4.Mg_2SiO_4$.

The following table shows the relation between the characters of the olivine and those of hortonolite and fayalite:

	Olivine of El Nakhla.	Hortonolite.	Fayalite.
α ...	1·75	1·7684	1·8236
β ...	1·785	1·7915	1·8642
γ ...	1·80	1·8031	1·8736
$\gamma-\alpha$ ...	0·05	0·0347	0·0500
2V ...	67°	69°	50½°
Sp. gr. ...	3·98	4·038	4·318

Chemical Composition.

A bulk-analysis of the meteorite was made by the usual methods of rock-analysis. For the determination of ferrous iron and water the material was crushed (not powdered) until the whole passed through a sieve of 80 meshes to the inch. No barium, zirconium, or strontium was detected. The result of the analysis is given under I. Under II and III are given the results obtained by W. B. Pollard [1] and S. Meunier [2] respectively.

	I.	II.	III.
SiO_2 ...	48·96	49·98	47·40
TiO_2 ...	0·38	—	—
Al_2O_3 ...	1·74	1·65	0·69
Cr_2O_3 ...	0·33	0·23	—
Fe_2O_3 ...	1·29	—	—
FeO ...	19·63	19·58	20·80
MnO ...	0·09	—	0·85
CaO ...	15·17	15·12	15·20
MgO ...	12·01	12·20	14·61
Na_2O ...	0·41	—	0·05
K_2O ...	0·14	—	
...	0·06	—	—
H_2O at 110° ...	0·07	0·35	—
H_2O above 110° ...	0·17		—
	100·45	99·11	99·60
Specific gravity [3] ...	3·47	3·40	3·388

[1] J. Ball, loc. cit., p. 8.

[2] S. Meunier, Compt. Rend. Acad. Sci. Paris, 1911, vol. cliii, p. 786.

[3] In I as determined on 1·0065 gram of the coarsely powdered stone.

Weight of material used in analysis: for main analysis, 1·0078 gram; for alkalis, 0·5368 gram; for ferrous iron, 0·5170 gram; for sulphur, 0·9545 gram; for water, 0·5366 gram.

In order to determine the proportion of soluble to insoluble silicates in the meteorite, 4·6782 grams were digested in hydrochloric acid of sp. gr. 1·06 in the usual way,[1] except that for the decomposition of the olivine two digestions of about twenty minutes' duration were considered sufficient. The insoluble, after treatment with sodium carbonate to remove silica, amounted to 3·9851 grams. The analysis of the soluble portion gave the following result, confirming the composition of the olivine given on p. 278:

SiO_2	... ...	33·06
FeO	... ...	51·67[2]
CaO	... ...	1·86
MgO	... ...	13·03
		99·62

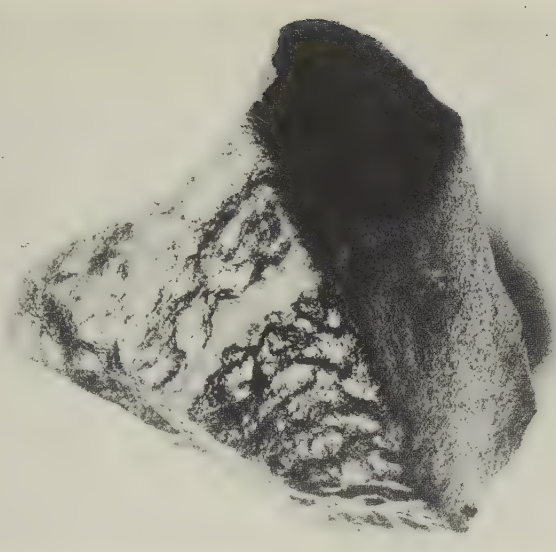
The mineral composition of the meteorite, as calculated from the results of the bulk-analysis and from the known composition of the olivine is as follows:

$Na_2O . Al_2O_3 . 6SiO_2$	...	3·46			
$K_2O . Al_2O_3 . 6SiO_2$	...	0·83	...	6·76	... Felspar
$CaO . Al_2O_3 . 2SiO_2$	...	2·47			
$FeO . Fe_2O_3$	...		...	1·87	... Magnetite
$FeO . TiO_2$	...		...	0·73	... Ilmenite
$FeO . Cr_2O_3$	...		...	0·49	... Chromite
FeS	...		...	0·17	... Troilite?
$CaSiO_3$	...	30·54			
$FeSiO_3$	...	21·00	...	76·70	... Diopside
$MgSiO_3$	...	25·16			
Fe_2SiO_4	...	9·87			
Mg_2SiO_4	...	3·38	...	13·25	... Olivine
H_2O	...		...	0·24	... Water
				100·21	

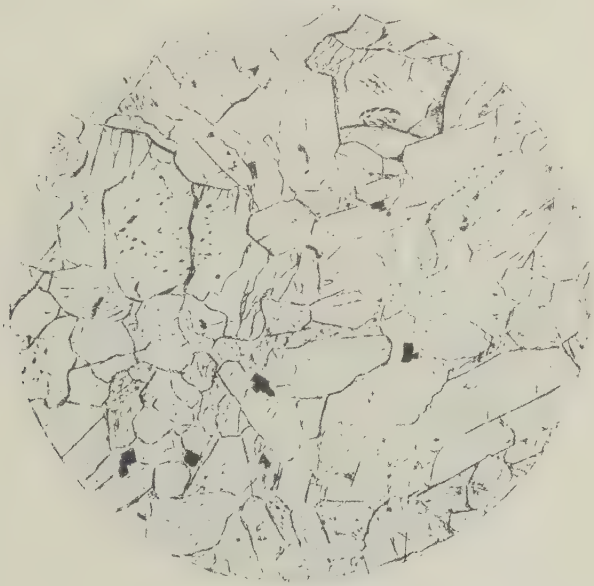
As regards classification, the meteorite of El Nakhla approaches most closely to the angrite group as represented by the meteorite of Angra dos Reis, Brazil. Like the Egyptian meteorite, this stone contains no

[1] L. Fletcher, Mineralogical Magazine, 1894, vol. x, p. 288.

[2] All the iron is estimated as ferrous oxide.



1.



. C. S. del. 2.

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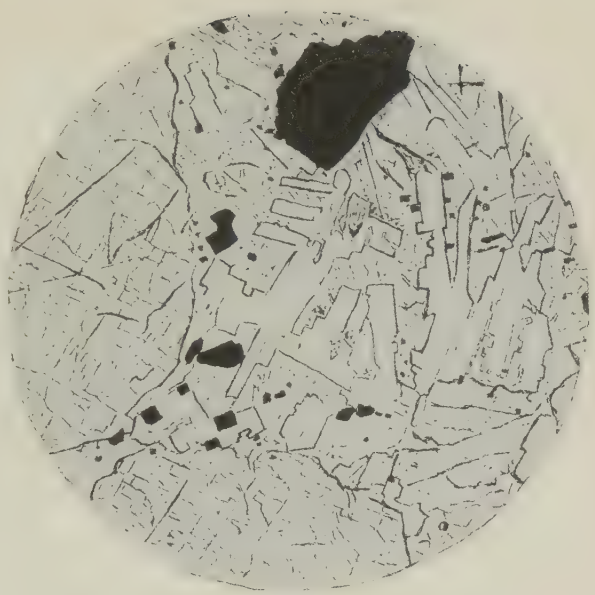

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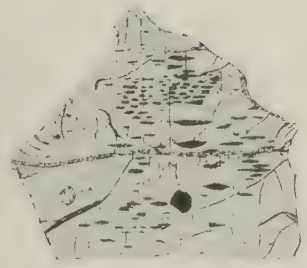
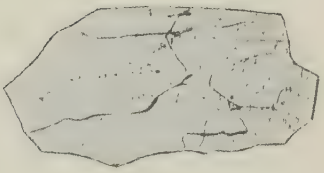


2.



3.

W. C. S. del.

4.

G. T. Prior: The El Nakhla Meteoric Stone.

metallic iron and consists mainly of augite and olivine: the augite, however, is a dark purple, titaniferous variety, and amounts to more than 90 per cent. of the stone.

Explanation of Plates.

(The drawings have been made by Mr. W. Campbell Smith, Assistant in the Mineral Department, British Museum.)

Plate IX.

Fig. 1. Reproduction of photograph (taken from above) of a stone, weighing 1·5 grams, of the El Nakhla meteorite (see p. 275), showing encrusted surfaces: those on the right, smooth faces with fine network of fused ridges; those on the left, rough faces with more glossy crust. $\frac{3}{4}$ natural size.

Fig. 2. Thin section of meteorite of El Nakhla (see p. 275), showing diopside in prismatic sections twinned on (100) and (001); olivine in larger clear irregular grains with black inclusions; and interstitial felspathic material, of which two patches can be seen below the diopside showing herring-bone structure at the bottom of the slide on the right. Magnification, 23 diameters.

Plate X.

Fig. 1. Thin section of meteorite of El Nakhla (see p. 276), showing interstitial material consisting of felspar-laths, grains and sub-ophitic plates of diopside, and grains of magnetite. Magnification, 165 diameters.

Fig. 2. Section of olivine normal to obtuse positive bisectrix (see p. 277), showing inclusions as lenticular plates with long axes parallel to the line joining the optic axes. Magnification, 30 diameters.

Fig. 3. Section of olivine normal to acute negative bisectrix (see p. 277), showing the traces of the inclusions as sharp lines, all directed at right angles to the line joining the optic axes. Magnification, 30 diameters.

Fig. 4. One of the inclusions in the olivine as seen highly magnified in a section normal to obtuse positive bisectrix (see p. 278). Magnification, 365 diameters.

Description of large crystals of Seligmannite and Dufrenoysite.[1]

By R. H. Solly, M.A.

[Read November 12, 1907, and November 14, 1911.]

I. Seligmannite.

In the summer of 1906 some large crystals of seligmannite were found in an irregular, elongated cavity in the dolomite-rock of the Lengenbach quarry at Binn, Switzerland. Owing to their brittle nature many of them were broken when the rock was blasted, but I was in the quarry at the time and collected all the fragments. The largest crystal broke after it had been measured, and Dr. G. T. Prior's analysis[2] II was made on portions of it, his other analysis, I, being made on measured crystal fragments found with the large crystal. The streak of the present crystals is black and inclined to purplish in colour, while that of the crystals first described by me[3] was chocolate-coloured. Previously no cleavage had been observed, but these crystals show poor cleavages in the same directions as in the case of bournonite, viz. parallel to (100), (010), (001). The crystals examined were of three different types of habit.

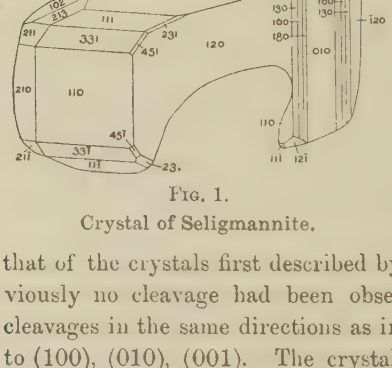


Fig. 1.
Crystal of Seligmannite.

[1] The drawings illustrating this paper were prepared by Dr. G. F. Herbert Smith. In order to identify certain of the faces he measured the smaller crystals on the three-circle goniometer in the British Museum and found a few additional new forms on the second crystal of dufrenoysite, which have been incorporated in the list given on p. 286.

[2] G. T. Prior, Mineralogical Magazine, 1910, vol. xv, p. 385, where, through a misunderstanding, it was stated that the analysis was made on fragments of another crystal, which had been found by me in 1905, and described in Mineralogical Magazine, 1906, vol. xiv, p. 186.

[3] R. H. Solly, Mineralogical Magazine, 1903, vol. xiii, p. 337.

Type 1.—The largest of the crystals, on which analysis II was made, belongs to this type. Before fracture it measured 20 mm. in length; part of it, measuring 9 mm. in length, is depicted in fig. 1. The crystal, now in three pieces, is in the British Museum.[1] It is intimately associated with rathite, the boundary between the two minerals crossing the face (120) by the curved line (fig. 1). Altogether twenty-six forms were found, of which the first six were largely developed and the last eight new to the species:

m(110), f(120), b(010), e(210), u(112), a(100), c(001), n(011), o(101), i(130), ρ(121), K(161), y(111), ϕ(113), C(311), 3 p(331), ι(213), II(132), k(540), Ψ(450), Φ(140), α(160), Θ(180), β(181), γ(541), ζ(451).

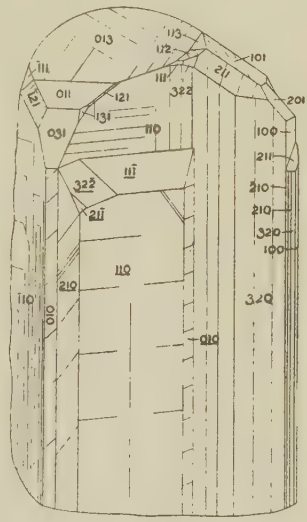


Fig. 2.
Crystal of Seligmannite.

Type 2.—This type differs little from the preceding, but the (210) and (120) planes are marked with fine triangular striations similar to those sometimes seen on the octahedron faces of a cubic crystal. I found six new forms on crystals of this type, viz. λ(781), μ(561), (341), J(651), π(972), δ(752).

Type 3.—This type is distinguished by the prominent development of the face (013), as is shown in fig. 2, which depicts a fine twinned crystal (twin-plane (110)), measuring 6 by 5 mm. At the junction corner of the two individuals of this crystal, close to the planes (031) and ($32\bar{2}$) and on the smaller individual, are some very small planes whose indices are probably (703), (14. 1. 1), (11. 2. 2). The face (110) is striated parallel to (001) and (100); (010) to (001) and (111); (121) to (010); and (130) to (001). Attached to this crystal, on the right in the figure, is a smaller one in nearly parallel position with the larger individual.

The indices of the new forms were based upon the following angles; in certain instances the exact position was determined from the fact that two well-marked zones intersected in the plane.

[1] Registered number 1906, 411.

Angle.		Calculated.[1]		Observed.
100 : 540	...	36° 37′	...	36° 20′
: 450	...	49 5½	...	49 1
: 140	...	74 51	...	74 50
: 160	...	79 46	...	79 42
: 180	...	82 17½	...	82 16
010 : 181	...	11 9	...	11 5
110 : 541	...	11 28½	...	11 25
: 451	...	11 41½	...	11 45
: 781	...	7 3	...	7 15
: 561	...	9 36	...	9 38
: 341	...	14 56	...	14 10
: 651	...	9 27½	...	9 20
: 972	...	12 50½	...	12 46
: 752	...	16 52	...	16 37

Altogether seventy-one definite forms have now been observed o seligmannite.

II. Dufrenoysite.

Some interesting crystals of dufrenoysite associated with seligmannit were discovered on breaking open a small cavity in the dolomite-rock o the Lengenbach quarry on August 1, 1911. I saw lying loose in th cavity a large, brilliant crystal of dufrenoysite with a number of simila but smaller crystals, while other crystals together with pyrites and blend were adhering to the sides. The loose crystals exhibit a dull conchoid fracture, and on the broken surfaces are deposited numerous minut crystals of seligmannite, which must therefore have been formed after th fracture of the dufrenoysite crystals.

The large crystal (fig. 3) above mentioned measures 25 × 16 × 6 mm and is by far the finest I have ever seen, being even larger than the on described by Professor Baumhauer.[2] The crystal is now in the Britis Museum.[3] The crystal is twinned[4] about (001), and is developed at bot ends; at the lower end (fig. 3) the individual on the left, owing to wan of uniformity of growth, is divided into two parts in parallel positio Certain of the faces in the zone [010 : 001] are finely striated parallel t

[1] The calculated values are based upon the data given in my previous pape Mineralogical Magazine, 1903, vol. xiii, p. 336.

[2] H. Baumhauer, Zeits. Kryst. Min., 1897, vol. xxviii, p. 551.

[3] Registered number 1912, 144.

[4] Twinned crystals of dufrenoysite have not before been described. The fir was found by me in the Lengenbach quarry in 1906, and is now in the Britis Museum collection (Registered number 1906, 412).

their mutual edges; the face (121) is rough and 12$\bar{1}$ is pitted. Altogether the following sixty-three forms were observed on this crystal: (0. 11. 1), (081), (071), (061), (051), (092), (041), (072), (031), (0. 11. 4), (052), (0. 11. 5), (021), (0. 11. 6), (074), (0. 17. 10), (053), (0. 11. 7), (032), (054), (076), (011), (056), (034), (035), (012), (025), (014), (130), (120), (590), (230), (670), (560), (110), (760), (750), (530), (740), (210), (720), (121), (232), (111), (212), (414), (12$\bar{1}$), (23$\bar{2}$), (11$\bar{1}$), (21$\bar{2}$), (525), (43$\bar{2}$), (533), (32$\bar{2}$), (543), (33$\bar{1}$), (54$\bar{2}$), (32$\bar{1}$), (100), (010), (001), (101), (20$\bar{1}$). Of these (533), (32$\bar{2}$), (543), (33$\bar{1}$), (54$\bar{2}$), (32$\bar{1}$) are very narrow

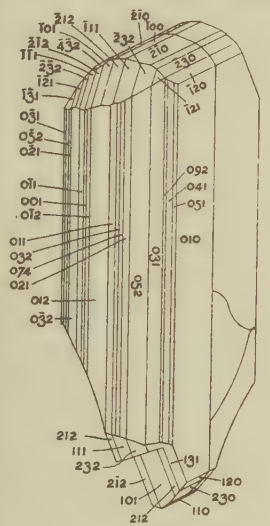


Fig. 3.

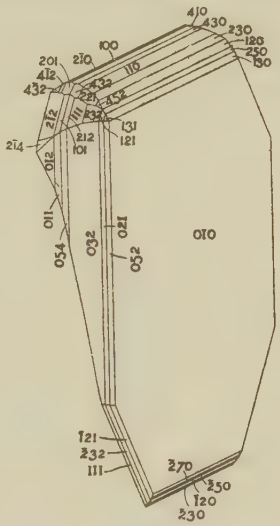


Fig. 4.

Crystals of Dufrenoysite.

planes lying on the edges between (43$\bar{2}$) and (10$\bar{1}$), (21$\bar{2}$), (11$\bar{1}$), (230), (110), (210) respectively, the position in each case being taken to correspond to the maximum amount of reflected light given on the goniometer.

The next largest crystal (fig. 4) is much smaller and measures only 4 × 7 × 4 mm.; it also is in the British Museum.[1] It was one of the close crystals, and its broken surface is partially covered with minute crystals of seligmannite. Its lustre is brilliant, and the faces afford extremely sharp reflections of the object-slit of the goniometer. Unlike the large crystal, it is simple and not twinned. It is remarkable for the number of its pyramid-zones, twelve in all: those connecting (010) with (101), (201), (10$\bar{1}$), (20$\bar{1}$) are well developed, and the face (214) is fairly

[1] Registered number 1912, 542.

large, but in the remaining pyramid-zones the faces are minute. Alt gether the following sixty-four forms were observed: (010), (041), (072 (031), (052), (021), (074), (053), (032), (043), (054), (076), (011), (056 (034), (012), (013), (014), (270), (130), (250), (120), (350), (230), (450 (110), (320), (430), (210), (410), (131), (252), (121), (232), (454), (111 (434), (212), (13$\bar{1}$), (12$\bar{1}$), (37$\bar{3}$), (23$\bar{2}$), (11$\bar{1}$), (53$\bar{5}$), (21$\bar{2}$), (31$\bar{3}$), (231 (452), (221), (432), (211), (643), (412), (43$\bar{2}$), (21$\bar{1}$), (41$\bar{2}$), (214), (100 (201), (101), (102), (001), (10$\bar{1}$), (20$\bar{1}$).

Among the forms found on the two crystals are thirty which are nev viz.: (0. 11. 1), (071), (061), (0. 11. 6), (0. 11. 7), (076), (025), (750), (320 (740), (720), (450), (131), (37$\bar{3}$), (12$\bar{1}$), (52$\bar{5}$), (53$\bar{3}$), (54$\bar{3}$), (33$\bar{1}$), (54$\bar{2}$ (32$\bar{1}$), (32$\bar{2}$), (13$\bar{1}$), (454), (434), (53$\bar{5}$), (21$\bar{2}$), (31$\bar{3}$), (643), (214). The with the one hundred and three forms given in my previous paper[1] bring th number of forms found for dufrenoysite up to one hundred and thirty-thre

In the following table are given some of the measurements, particular those relating to new forms, made on the crystals. It will be noticed ho closely the angles on the second crystal agree with the calculated value.

First Crystal.			Second Crystal.		
Angle.	Calculated.	Observed.	Angle.	Calculated.	Observe
100 : 100	1° 7′	1° 5′	100 : 201	28° 6½′	28° 7
100 : 10$\bar{1}$	46 26¾	46 25	: 101	47 2¼	47 2
$\bar{1}$00 : $\bar{1}$0$\bar{1}$	46 26¾	46 30	: 102	65 15½	65 15
010 : 0·11·1	8 26½	8 30	: 20$\bar{1}$	27 51½	27 51
: 071	13 7½	13 1	: 10$\bar{1}$	46 26¾	46 26
: 061	15 13	15 8	: 00$\bar{1}$	89 27	89 26
: 0·11·6	41 41	42 1	010 : 076	54 27	54 25
: 0·11·7	46 5½	46 30	: 320	66 32½	66 10
: 076	54 27	54 24	: 131	36 38	36 40
: 025	76 14	76 12	: 454	60 44	60 43
: 750	65 4	65 5	: 434	71 25	71 29
: 740	69 36	69 27	: 643	68 57	68 59
: 720	79 28	79 21	: 214	82 5	82 3
			: 13$\bar{1}$	36 54	37 0
			: 37$\bar{3}$	43 59	44 0
			: 12$\bar{1}$	48 23½	48 30
			: 53$\bar{5}$	75 5	75 10
			: 31$\bar{3}$	81 35	81 20

[1] R. H. Solly, Mineralogical Magazine, 1902, vol. xiii, pp. 160-171. In the l of forms on p. 165 four—(221), (432), (211), (412)—were omitted, and t number of forms was 103 and not 99 as there stated.

[2] Based on the data given on p. 162, loc. cit.

Hatchite, a new (anorthic) mineral from the Binnenthal.[1]

By R. H. Solly, M.A.

and G. F. Herbert Smith, M.A., D.Sc., F.G.S.

Assistant in the Mineral Department of the British Museum.

[Read January 23, 1912.]

NEARLY ten years ago, in 1902, five small crystals were noticed by one of us on a crystal of a sulpharsenite of lead, probably rathite, which had been found in the Lengenbach quarry that summer. Although from their lead-grey colour they also appeared to belong to a sulpharsenite of lead, in habit and appearance they were unlike the crystals of any such species as yet known. The crystals were measured, and were shown at the anniversary meeting[2] of the Society, November 18, 1902, but the measurements were not published at the time in the expectation that further material would afterwards be found which would enable an analysis to be made and perhaps throw fresh light on the morphological characters of the crystals. Such hopes have not yet been realized, and, since it is uncertain how much sustained work may be done in the quarry in the future, it was felt desirable not to delay longer the publication of the results of the goniometrical examination.

Four of the crystals were sent to the British Museum last year (1911), and were measured on a three-circle goniometer. Only two of them (figs. 1 and 2) were sufficiently well developed to be of service in the determination of the morphological characters; the former of them

[1] Communicated by permission of the Trustees of the British Museum.

[2] Mineralogical Magazine, 1902, vol. xiii, p. xxxi. The following report appeared in 'Nature', 1902, vol. lxvii, p. 142: 'Mr. Solly also discussed the crystallography of a presumably new mineral from the Lengenbach, five minute but brilliant crystals of which were found on a crystal of rathite. In these crystals, no plane or axis of symmetry could be determined, and each crystal was grown in a different position.'

measured about 0·7 mm., and the latter about 0·5 mm. in greatest diameter. The crystals displayed the following combinations of forms:

Crystal 1 (fig. 1), *a b c m n l M d r u o v i q w p*.
Crystal 2 (fig. 2), *a b c m M g f r o i q j s*.
Crystal 3, *b c M r o*.
Crystal 4, *a b c M r s*.

The crystals are lead-grey in colour, and give a chocolate-coloured streak. They possess neither plane nor axis of symmetry, and belong therefore to the anorthic system; no signs of twinning were noticed. They have to some extent lost their original brilliance of lustre during the years that have passed since they were found, and the reflections of the goniometer-signal were correspondingly less distinct, but the values of the angles agreed closely with the earlier determinations.

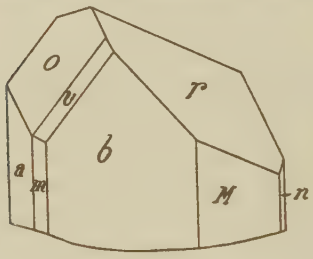


Fig. 1.

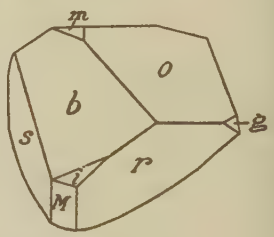


Fig. 2.

Crystals of Hatchite from the Binnenthal, Switzerland.

The following angles, which were the best of those measured, were used in the calculation of the axial ratios and angles:

Angle.	Observed Values.	Mean Value.
$ab = (100):(010)$	65° 45′, 65° 47′	65° 46′
$br' = (010):(\bar{1}1\bar{1})$	75° 59′, 76° 5′	76° 2′
$ar = (100):(1\bar{1}1)$	56° 10′, 56° 12′	56° 11′
$bc = (010):(001)$	62° 41′	62° 41′
$ao = (100):(11\bar{1})$	35° 55′, 36° 15′	36° 5′

$a:b:c = 0{\cdot}9787:1:1{\cdot}1575$; $\alpha = 116° 53\frac{1}{2}'$, $\beta = 85° 12'$, $\gamma = 11$ $44\frac{1}{2}'$; (010):(001) = 62° 41′, (001):(100) = 83° $4\frac{1}{2}'$, (100):(010) = 65° 4

Altogether twenty-one forms were observed: *a* (100), *b* (010), *c* (001) *m* (110), *n* (2̄10), *l* (3̄20), *M* (1̄10), *g* (01̄2), *e* (01̄1), *f* (02̄1), *d* (10 *r* (1̄11), *u* (22̄1), *o* (11̄1), *v* (12̄1), *i* (25̄1), *q* (25̄6), *j* (13̄6), *w* (32 *p* (1̄11), *s* (1̄12). Of these *a b c M o r* are the most prominent.

The observed and calculated values of the principal angles are stat in the following table, measurements being given from *b* (010):

Form.	Calculated Values.		Observed Values.	
	ϕ	ρ	ϕ	ρ
a (100)	0° 0′	65°46′	0° 0′	65°45′
			,,	65 47
			,,	65 52
			,,	65 55
m (110)	,,	31 14	,,	31 27
			,,	31 41
n ($\bar{2}10$)	,,	−81 30	,,	81 35
l ($\bar{3}20$)	,,	−70 45	,,	70 56
M ($\bar{1}10$)	,,	−53 10	,,	53 35
				53 49
u ($\bar{2}2\bar{1}$)	23 35½	−63 15	23 14	63 13
i ($\bar{2}5\bar{1}$)	,,	−24 19½	23 46	24 21
			22 37	24 59
r ($\bar{1}1\bar{1}$)	42 12	−76 2	42 16	75 59
			41 48	76 6
d (103)	72 41½	56 22	73 22	56 19
c (001)	−85 12	62 41	85 0	62 41
			85 11	63 5
g (01$\bar{2}$)	,,	−79 6	85 0	79 15
e (01$\bar{1}$)	,,	−47 57½	84 5	48 8
f (02$\bar{1}$)	,,	−23 19	85 30	23 0
j (13$\bar{6}$)	−74 16	−74 48	73 38	75 0
q (25$\bar{6}$)	−64 56½	−52 43½	65 43	50 6
			65 56	54 40
s ($\bar{1}12$)	−55 53	51 26		
o (11$\bar{1}$)	−38 12	−48 20	37 58	48 40
			38 2	48 40
v (12$\bar{1}$)	,,	−29 27½	37 58	29 39
p ($\bar{1}11$)	,,	48 20	38 9	49 29
w (32$\bar{1}$)	−15 21	−43 52	15 34	44 9

s ($\bar{1}12$) was an indistinct face lying in a zone with M ($\bar{1}10$) and r (1$\bar{1}1$), the observed value of the angle sr = ($\bar{1}12$) : (1$\bar{1}1$) being 90° 40′ and the calculated value 92° 30½′.

So far as we have been able to ascertain no mineral species with similar morphological characters has yet been described. Since it therefore appears to be a new species, it is convenient to give it a name, and we propose to call it hatchite after Dr. Frederick Henry Hatch.

Note on a large crystal of Anatase from the Binnenthal.[1]

By G. F. Herbert Smith, M.A., D.Sc., F.G.S.

Assistant in the Mineral Department of the British Museum.

[Read January 23, 1912.]

LAST year (1911) the Trustees of the British Museum acquired a large isolated crystal of anatase,[2] which is of interest not only on account of its unusual size, but also because of the vicissitudes that, to judge from the furrowed appearance of certain faces, it had undergone in the course of growth. It was by far the largest of the many crystals of this species that were found in the previous year (1910) near the ridge Kollergraben in the district known to early mineralogists as Alp Lercheltini, probably at a spot named Spissen.[3]

Honey-yellow in colour and translucent near the surface, the crystal (fig. 1) measures about 26 mm. in length and 20 mm. in its greatest width. The development is imperfect underneath, especially at the back, where cling a few small crystals of anatase of similar habit as well as a little magnetite, adularia, and mica. In habit the crystal is similar to one from Spissen recently described by Desbuissons[4] and another from an earlier find in Alp Lercheltini described by Seligmann,[5] and like them it is remarkable for the predominance of a ditetragonal form. Crystals somewhat similarly distinguished were described from the Ofenhorn by Solly.[6]

[1] Communicated by permission of the Trustees of the British Museum.

[2] Registered number 1911, 182.

[3] Compare L. Desbuissons, 'Contribution à l'étude des minéraux de la vallée de Binn. 2° Anatase de Spissen.' Bull. Soc. franç. Min., 1911, vol. xxxiv, pp. 245–251. The number, though bearing date November, 1911, was not received at the Museum till February 3, 1912.

[4] Fig. 2, loc. cit.

[5] G. Seligmann, 'Anatas von der Alp Lercheltini im Binnenthal.' Zeits. Kryst. Min., 1886, vol. xi, pp. 337–343, plate V, fig. 3.

[6] R. H. Solly, 'On various minerals (Anatase, &c.) from the Binnenthal.' Mineralogical Magazine, 1904, vol. xiv, p. 16.

The unusual habit of the crystal and the curious contrast in the character of the surfaces of the various faces led me to examine it and determine the indices of the faces. The top (fig. 1) is formed of four brilliant faces which measurement proved to belong to the form $z(113)$. Smaller in size but equal in brilliancy were faces which in the same way proved to belong to the forms $e(101)$ and $k(112)$. In striking contrast as regards brilliancy are the faces of the ditetragonal form referred to and the large faces—obviously belonging to the form $a(100)$—that lie in the prism-zone; their surfaces are extremely rough, as indicated by the stippling in the figure, and such reflections as they afford of object-slit on the goniometer occur in unexpected directions: this peculiarity is more fully discussed below. The indices of the ditetragonal form may easily be determined from the directions of the edges of its faces. They must be of the type $(h13)$ on account of the parallelism of the opposite edges of $z(113)$ (fig. 1). Again, since the faces lying on opposite sides of $e(101)$ meet in parallel edges, the latter lies in the zone connecting $h13$ and $h\bar{1}3$, and therefore $h = 3$ and the faces belong to the form $\tau(313)$, which is also the dominating form of the crystals described by Desbuissons and Seligmann.

The crystal was measured on a one-circle goniometer as far as was necessary to establish the indices of the faces, and altogether the following ten forms were observed:

$a(100)$, large, rough, no reflections corresponding to its apparent position.

$\tau(313)$, very large, rough, no reflections corresponding to its apparent position.

$z(113)$, fairly large, bright, excellent reflections.

$k(112)$, small, bright, good reflections.

$p(111)$, very small, bright, good reflections.

$e(101)$, small, bright, good reflections.

$m(110)$, minute, bright, distinct reflections.

$\delta(331)$, minute, bright, distinct reflections.

$\vartheta(532)$, minute, dull, faint reflections.

$h(513)$, minute, dull, faint reflections.

The measurements made are tabulated below and compared with the corresponding values calculated from the axial ratio quoted in Dana's 'System of Mineralogy', sixth edition. The want of close agreement which will be noticed in certain instances is due partly to the indistinctness of the corresponding reflections, and partly to the slight distortion which exists, as in large crystals generally.

Form.	Calculated Values.	Observed Values.
$zz'' = (113) : (\bar{1}\bar{1}3)$	79° 54½′	79° 54′
$kk'' = (112) : (\bar{1}\bar{1}2)$	102 58½	103 4, 103° 30′
$pp'' = (111) : (\bar{1}\bar{1}1)$	136 36	136 34, 136 46
$ee'' = (101) : (\bar{1}01)$	121 16	120 3
$zz' = (113) : (\bar{1}13)$	54 1	54 19
$hh' = (513) : (\bar{5}13)$	136 52	137 9
$pe = (111) : (101)$	41 4	40 54
$\vartheta m = (532) : (110)$	17 43	18 15

The form ϑ was determined from the angle quoted and the fact that it lay in the zone connecting $m(110)$ and $e(101)$; it occurs on the crystal described by Seligmann.

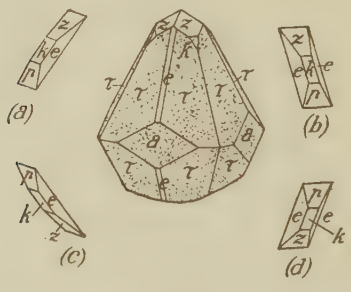


Fig. 1.—Crystal of Anatase. The smaller figures show the nature of the secondary development on the surfaces τ.

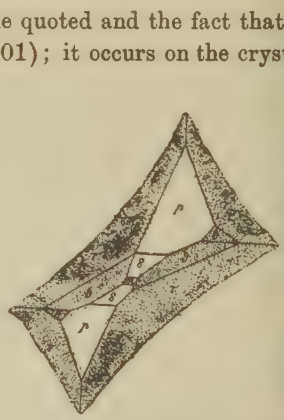


Fig. 2.—One coign of the same crystal.

The arrangement of the small faces lying near $m(110)$ (fig. 2) is interesting and suggests that the full tetragonal symmetry is lacking. The other coign shown in the figure is imperfect and those that should be at the back have not been developed, so that the evidence is insufficient to be conclusive.

It has been stated above that the reflections from the ditetragonal faces are not such as would be expected. They, as a matter of fact, correspond to the forms $z(113)$, $k(112)$, $p(111)$, and $e(101)$, and examination with a lens shows that each face has been replaced by numberless tiny crystals characterized by these forms and having the same orientation as the main crystal, but without any regularity in size or arrangement. The development on each pair of faces in the same octant is identical in character; thus (fig. 1) crystals of the type (*a*) lie on both (3$\bar{1}$3) and (133), crystals (*b*) on (313) and (133), and so on in each of the four

octants to the front. The reflections from $a(100)$ are simpler and correspond to $e(101)$ only.

It may be surmised that at some stage in the development of the crystal the growth was checked and slight dissolution took place, the forms τ and a proving susceptible to attack. Eventually growth was resumed, but under changed conditions which favoured the formation of crystals of a different habit.

The Trustees recently (1912) acquired smaller examples of anatase of the same occurrence, which are similar in habit to the large crystal just described. The forms observed comprise $a\ \tau\ z\ k\ p\ e\ \delta\ \vartheta$. The excrescent development on the faces of the form τ is, however, slightly different, the reflections obtained corresponding to the forms p and e in pairs, so that, for instance, the face (313) gave reflections corresponding to (101) and (111).

On Topaz and Beryl from the granite of Lundy Island.

By W. F. P. McLintock, B.Sc.

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and T. C. F. Hall, F.G.S., Assoc. Inst. M.M.

Lecturer in Geology and Mineralogy, School of Metalliferous Mining, Cornwall.

[Read June 18, 1912.]

ALTHOUGH topaz and beryl have been previously recorded from Lundy Island, no account has hitherto been published of their characters and mode of occurrence. In the summer of last year a geological survey of the Island was commenced by one of us, and during the progress of the work good crystals of these minerals were obtained, the results of an examination of which it seems desirable to place before this Society.

Previous Literature.

Previous contributions to the mineralogy of Lundy Island consist only of lists of minerals, with few or no particulars as to their characters and mode of occurrence.

The earliest reference we have been able to trace is one by Townshend M. Hall,[1] who, in 1868, recorded the occurrence of felspar, magnetite, rock-crystal, schorl, and copper-pyrites. The second and last of these minerals, however, occur only in the slates and will not be further alluded to here.

In 1870, S. G. Perceval[2] communicated to the 'Geological Magazine' a letter noting the occurrence of topaz, his observations being based on specimens in the collection of Dr. Alfred Day of Clifton, and on one obtained by Robert Etheridge. He remarked upon the similarity of the crystals to those of the Mourne Mountains.

[1] T. M. Hall, 'The Mineralogist's Directory,' London, 1868, p. 58.

[2] S. G. Perceval, 'On the occurrence of topazes in Lundy Island.' Geol. Mag. 1870, vol. vii, p. 192.

In a paper on the geology and mineralogy of the Island, in 1871, Townshend M. Hall[1] gave a list, with brief particulars, of those minerals which had been observed by him in the granite. Among them he noted beryl, but made no mention of topaz.

Lastly, J. H. Collins, in his 'Handbook to the Mineralogy of Cornwall and Devon',[2] states that topaz is 'said to have been found on Lundy Island'.

Mode of occurrence.

The granite, in which the minerals occur, occupies by far the greater portion of Lundy Island. At its south-east end it is in contact with a small area of slates which it has metamorphosed. These slates are presumably Devonian, but, in the absence of fossils, their age is a matter of doubt. Elsewhere the granite is bounded by the sea, so that it is impossible to speak with certainty as to its exact relations to the surrounding rocks.

Intrusive alike into granite and slate are a large number of dykes varying greatly in size and ranging in composition from acid to basic types.

The granite was formerly extensively quarried and exported, and, although the industry is now quite abandoned, the excavations left by the quarrymen offer facilities for the examination of the rock in greater detail than otherwise would have been possible. The material described in this paper was obtained from the most northerly of these quarries, situated on the east side of the Island, one mile due north of the church.

The rock at this locality is a muscovite-biotite-granite with a strong tendency to idiomorphism on the part of the quartz. This mineral is somewhat dark in colour, and stands out in striking contrast to the opaque white felspar.

Under the microscope the bulk of the rock is seen to consist of quartz, orthoclase, and much-twinned plagioclase. The quartz contains numerous cavities enclosing bubbles of gas in liquid; many of these cavities are of the nature of negative crystals. Other inclusions in the quartz are small zircons and, more rarely, grains of pink garnet. The orthoclase occurs in large plates with a tendency to rough intergrowths with the quartz, and appears cloudy and decomposed; some of it is perthitic.

[1] T. M. Hall, 'Notes on the Geology and Mineralogy of the Island of Lundy.' Trans. Devon. Assoc., 1871, vol. iv, p. 624.

[2] Truro, 1871, Part II, p. 101.

The plagioclase is sub-idiomorphic with respect to the quartz and orthoclase, and shows albite- and pericline-twinning. From a consideration of its refractive indices which, tested by the Becke method, are found to be less than those of quartz, and of the values of the symmetrical extinction-angles measured on the albite-lamellae of Carlsbad-twins, this plagioclase appears to be albite or albite-oligoclase. Topaz, in irregular grains, is fairly abundant; and a biaxial, optically negative mineral, having a well-developed cleavage, straight extinction, and faintly coloured pleochroic halos around inclusions, appears to be cordierite.

Traversing the granite are numerous veins of aplite. These, when examined microscopically, show abundant topaz in irregular grains. The quartz and felspar form an interlocking mosaic. The aplites often pass on the margins into coarse-grained pegmatites. In these pegmatites, but principally lining drusy cavities and fissures in the normal granite, occur well-shaped crystals of topaz and beryl, together with smoky-quartz, orthoclase, albite, mica, and, less frequently, tourmaline, fluor-spar, and apatite.

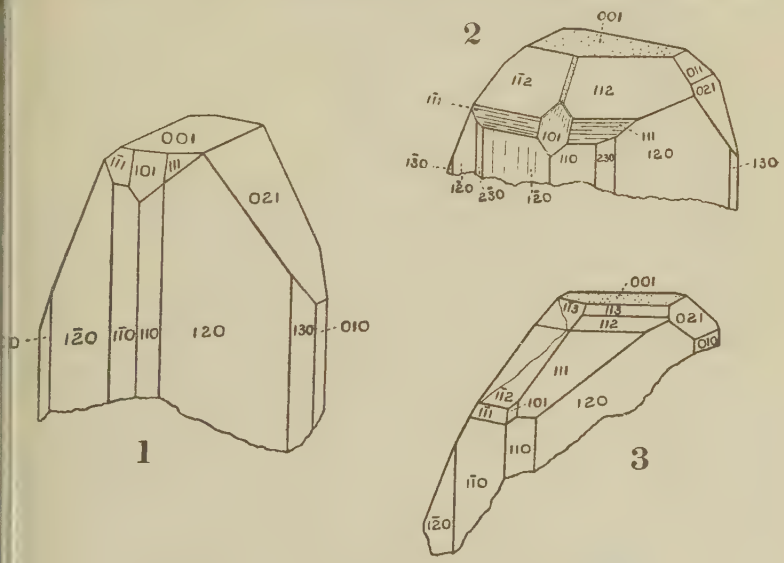
On one specimen a very small red grain occurs in felspar, and this has been identified as garnet. We are informed by Mr. Walter Heaven, the heir to the property, that this mineral has been found abundantly in places, being known on the Island as ruby! Amethyst is also stated to have been found, but so far none has been detected by us, and it is just possible that fluor-spar has been mistaken for it.

When the cavities containing these minerals are first broken open they are found to contain a powdery clay-like substance resembling kaolin. In this many of the smaller crystals of topaz and beryl are loosely embedded, so much so, in fact, that they are easily washed out by a stream of water. Faces of the druses which have been exposed to the atmosphere have, of course, most of this clay removed, but a certain amount is invariably found adhering to and investing the crystals.

Description of the Minerals.

Topaz.—This mineral is quite plentiful in the druses, and occurs as well-formed crystals—usually pale-blue in colour, but often almost colourless—of various sizes and habits. The largest one noted measures 1 cm. along the *b*-axis and 0·5 cm. along the *a*-axis, but this is exceptional, and the crystals are usually much smaller. The basal plane (001) is always present and is invariably etched and dull; on no crystal was a reflection obtainable from this face. Sometimes the etching has not gone far and the plane is merely roughened, but in many cases it has

een eaten into a set of sharp pyramids. On several specimens the orrosion has followed a cleavage-crack, and the upper and lower parts f the crystal fit into each other by a series of tooth-like projections. t is evident that, subsequent to their formation, the crystals of topaz ave been subjected to some powerful solvent which attacked and de-mposed them. Further proof of this is afforded by the occurrence of issected crystals with the spaces between the cracks and cleavages lined ith a white, silvery mica. The topaz is in intimate association with uartz, felspar, and, in some cases, with beryl or tourmaline; often, too



Figs. 1–3.—Topaz crystals from Lundy Island.

e clay-like substance already mentioned is present. As will be shown ter, this substance is not secondary mica, and is quite unlike the Steinmark'[1] associated with the topaz of some of the German localities. The common forms are {001}, {010}, {110}, {120}, {130}, {101}, 021}, {111}, whilst {230}, {112}, {113}, {011} are of rarer occur-nce. The crystals are usually prismatic parallel to the *c*-axis (fig. 1), d various unsymmetrical developments occur (figs. 2 and 3). Stria-on is common in the prism-zone, whilst etching is found on several anes in addition to (001) (fig. 2). On the crystal represented in fig. 3

[1] Cf. Hintze, 'Handbuch d. Mineralogie,' 1889, vol. ii, p. 112.

the faces $(1\bar{1}3)$ and $(11\bar{2})$ have been partly rounded. The following angles were measured on the crystals:

	Measured.	Calculated.[1]
$(110) : (1\bar{1}0)$ ...	55° 44′ ...	55° 43′
$(230) : (2\bar{3}0)$ ...	76 30 ...	76 50
$(120) : (010)$ ...	43 21 ...	43 24
$(130) : (010)$ ...	32 15½ ...	32 14
$(010) : (021)$ ...	27 42 ...	27 39
$(010) : (011)$ ...	46 28 ...	46 21
$(101) : (110)$ ...	39 22 ...	39 21
$(110) : (111)$ ...	26 10 ...	26 6
$(110) : (112)$ ...	44 24 ...	44 25
$(110) : (113)$ ...	55 47 ...	55 46

Beryl.—Whilst not so common as topaz, this mineral is comparatively abundant in the druses of the granite. It occurs as pale-yellow or, more rarely, as pale-blue or colourless prisms the largest of which measures 0·7 cm. in length and 0·3 cm. in breadth. They are commonly seated on felspar and, like the topaz, are sometimes invested by the clay-like substance already mentioned. The forms observed are $c\ \{0001\}$, $m\ \{10\bar{1}0\}$, $p\ \{10\bar{1}1\}$, $s\ \{11\bar{2}1\}$; fig. 4 represents one of the best crystals obtained. The prismatic faces are almost invariably striated vertically, but the basal plane and the pyramids are often bright and lustrous and yield good reflections. In some cases however, crystals show signs of corrosion, and it is interesting to note that the pyramidal faces seem to have been the most readily affected; crystals occur on which the basal plane and prismatic faces are quite bright whilst the pyramids are replaced by a corroded band.

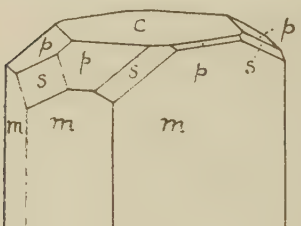


Fig. 4.—Beryl crystal from Lundy Island.

Quartz.—The quartz occurs in crystals of the usual habit up to an inch in length, and shows all variations in tint from black through pale brown to almost colourless. Sometimes the faces are dull and corroded but just as often they are bright and shining.

[1] Calculated from the elements given in Dana's 'System of Mineralogy,' 6th edition, 1892.

Felspar.—The felspars present some interesting features in hand-specimens. The crystals of orthoclase occur up to three-quarters of an inch in length, and are well formed. They have bright lustrous faces, but in many instances this appearance of freshness is deceptive, and, when scratched by a knife, the substance underneath is found to be quite soft and powdery. Sometimes the alteration has not proceeded far, but in other cases the whole crystal is friable and readily falls to powder. There is little doubt that the decomposition product is, in part at least, kaolin, and on some specimens little rectangular hollows filled with a clay-like substance are quite common. This question of the alteration of the orthoclase will be considered more fully in the sequel.

Crystals of albite are of frequent occurrence in the druses, but they are not so plentiful nor so large as those of the potash-felspar. They sometimes take the form of large plates showing the characteristic striation, or they may be found as small crystals perched on the smoky-quartz or on the orthoclase. In contrast to the latter mineral, the albite is always perfectly hard and fresh besides being much clearer; its identity was established by a determination of its refractive index (about 1·534) with suitable oils.

Mica.—White and brown micas occur as crystals and plates. They fuse readily in the blowpipe-flame and impart a strong red coloration to it, thus showing the presence of lithium.

Tourmaline.—This mineral is occasionally found as stout, black prisms, vertically striated and trigonal in section. It occurs in intimate association with felspar, and is sometimes partially invested by the clay-like substance.

Fluor-spar.—Small octahedra of purple fluor-spar have been observed on one or two specimens. They are usually seated on felspar, and sometimes form crusts on the larger crystals of orthoclase, which are powdery and decomposed. Sometimes the fluor-spar itself is coated with a thin film of clay, which gives it a strong resemblance to a pseudomorph.

Apatite.—Small, bluish prisms of this mineral have been detected, but they are by no means common, and the resemblance to the pale-blue beryl is so strong that the species is exceedingly apt to be overlooked. The pale-blue apatite can be distinguished, however, by its inferior hardness and by the fact that the prisms are soluble in acid, the solution so obtained reacting for phosphate. On one specimen a small terminated prism was observed, the basal plane and pyramidal faces being developed. Unfortunately, on an attempt being made to detach the crystal for measurement, it went to pieces, and, as no other terminated one has been noted, the forms have not been determined.

Kaolinization.

In the foregoing description reference has been made repeatedly to a clay-like substance which is present on every specimen of the pegmatites examined. It occurs in comparatively large masses, white to pale-yellow in colour, and intimately associated with felspar, topaz, beryl, fluor-spar, and tourmaline. It sometimes fills square-shaped hollows which obviously represent felspar crystals, and an almost perfect pseudomorph of felspar in it has been observed.

When some of the powder is crushed and examined in oil under the microscope it is seen to consist of aggregates of minute scales which are weakly doubly-refracting, and which have a refractive index (tested in oil) of 1·564. The water-content of the clay is about 13·1 per cent. (it lost about 2·5 per cent. in a desiccator), and its specific gravity is 2·32. These characters—especially the optical ones—agree fairly well with those of kaolinite, although the specific gravity is somewhat low.

It has already been noted that the large crystals of orthoclase are frequently powdery and decomposed, whilst those of albite are invariably fresh and clear. By boiling specimens in Canada-balsam it was possible to get sections made through some of the more completely decomposed portions of the rock, and an examination of these amply confirmed the evidence of selective kaolinization of the orthoclase afforded by the large crystals. In every case the orthoclase, or microperthite, shows signs of alteration, which takes the form of a development of kaolin with subordinate secondary mica. The albite, on the other hand, appears to have offered a stout resistance to the kaolinizing agent, with the result that clear and fresh plates of that mineral project into, or are completely enclosed by, large crystals of orthoclase more or less completely kaolinized. Dr. J. S. Flett mentions in the St. Austell memoir[1] the abundance of albite in the Cornish china-stones, and also the fact that it resists micaization better than orthoclase, although it is quite as susceptible to kaolinization. In the Lundy Island specimens there is no special abundance of secondary mica, whilst kaolin is exceedingly common and it has been derived chiefly from the orthoclase and microperthite. In the most thoroughly decomposed parts, however, the albite has also suffered change into kaolin and mica.

Mr. F. H. Butler in his papers[2] in this Magazine puts forward the

[1] 'The Geology of the Country around Bodmin and St. Austell.' Mem. Geol. Survey, 1909, p. 117.

[2] F. H. Butler, 'Kaolinization and other changes in West of England rocks.'

iew that carbonic acid was the main agent in the kaolinization of the rocks of the West of England. He points out that minerals like topaz nd tourmaline are unaffected by acids but are eroded by alkaline arbonates at a high temperature. He also remarks upon the presence f traces of china-clay in the tourmalinized rocks of the West of ngland, and ascribes the erosion of the tourmaline[1] to the alkaline arbonates set free during the kaolinization of the felspar. The speci-ens from Lundy Island would seem to support this view. Here there s a fair development of kaolin and topaz, the crystals of the latter ineral being invariably etched, eroded, and, in some cases, altered to silvery white mica. It is quite conceivable that, with the development f kaolin from felspar by carbonic acid, the alkaline carbonates so formed ay have attacked the topaz with formation of fluorides which, meeting ith compounds of lime, would give rise to the crusts and crystals of luor-spar.

The question of the age[2] of the granite of Lundy Island may well be eft until the survey has been completed. The occurrence of drusy avities containing such minerals as smoky-quartz, albite, topaz, beryl, ctahedral fluor-spar, &c., recalls the granite of the Mourne Mountains n Ireland,[3] although it is interesting to note that the felspars of that ock are not kaolinized.

The specimens upon which the above observations were made have een deposited in the Museum of Practical Geology, Jermyn Street, ondon.

We take this opportunity of expressing our indebtedness to Dr. J. S. lett and Mr. H. H. Thomas, of H.M. Geological Survey, for valuable uggestions, and to Mr. W. F. Saunt, the lessee of the Island, for ever-eady assistance in the field.

ineralogical Magazine, 1908, vol. xv, pp. 128–146. 'The brecciation of mineral-eins,' ibid., 1911, vol. xvi, pp. 124–135.

[1] F. H. Butler, loc. cit. (1908), p. 136.

[2] Cf. J. W. Judd, Quart. Journ. Geol. Soc., 1874, vol. xxx, p. 275 (footnote); . Harker, 'Tertiary Igneous Rocks of Skye.' Mem. Geol. Survey, 1904, p. 2 footnote).

[3] J. J. H. Teall, 'British Petrography,' 1888, p. 329.

Note on the occurrence of Strüverite in Perak.

By J. B. Scrivenor, M.A., F.G.S.

Geologist to the Federated Malay States Government.

[Read June 18, 1912.]

In a recent number of the Mineralogical Magazine an analysis o strüverite found in Perak was published.[1] This mineral was sub mitted to me by Mr. R. L. Corbett for examination in August, 1909 and as I failed to detect its relation to the Piedmont strüverite describe shortly before,[2] the material was forwarded to the Imperial Institute i accordance with an arrangement between the Institute and the Federate Malay States Government. While waiting for the results of the analysis the locality from which the mineral came was traced and some prospectin work carried out to ascertain the amount of material available. Thi work afforded information that is of interest concerning the origin o the mineral.

The locality, as already described,[3] is in the narrow valley of th river Sebantun, near Salak North. This stream flows over granite i the higher part of its course, but before the alluvium with strüverite i reached there is evidence that the granite margin has been passed an that the stream flows over hardened black shales. The old mining lo now cancelled, wherein the strüverite occurs, could not be worked fo tin-ore on account of the difficulty of separating the strüverite. Up stream, however, mining for tin-ore has been carried on extensively This, coupled with the fact that no strüverite was found over th granite or immediately beyond the granite margin, points to a sourc close to or in the old mining lot. The ground was prospected by mean of pits and a small opencast mine in the shallow alluvium. Below pa of the alluvium a mass of kaolin was found that agreed in constitutio

[1] T. Crook and S. J. Johnstone, 'On strüverite from the Federated Mala States.' Mineralogical Magazine, 1912, vol. xvi, pp. 224–23[illegible].

[2] G. T. Prior and F. Zambonini, 'On strüverite . . .' Mineralogical Magazin 1908, vol. xv, p. 78.

[3] Loc. cit., p. 224.

ith certain veins of kaolin known to be connected with granite and to t older beds, in Kinta, not very far away. A large quantity of this aolin was washed and yielded a few pieces of strüverite.

Although, therefore, the covering of alluvium makes it impossible to peak with certainty, the evidence obtained points to the strüverite curring as an original mineral in a vein of kaolin intrusive into rdened black shales, and to its having been concentrated in the luvium by the river Sebantun. The relation of the Kinta kaolin veins the granite and the occurrence of kaolin under the alluvium of the er Sebantun not very far from the granite margin suggests that, as in e cases of the Piedmont and South Dakota[1] strüverite, the mineral me from an acid magma.

[1] Amer. Journ. Sci., 1911, ser. 4, vol. xxxi, p. 432.

REVIEWS.

Dana's Manual of Mineralogy, for the student of elementary mineralogy, the mining engineer, the geologist, the prospector, the collector, etc. By WILLIAM E. FORD. 13th edit. entirely revised and rewritten. Pp. viii + 460, with 357 text-figures and 10 plates. (New York: John Wiley & Sons; London: Chapman & Hall, 1912. Price $2.00 = 8*s.* 6*d.* net.)

J. D. Dana's well-known 'Manual' first appeared in 1848 and was last revised in 1887, but it has often been reprinted and there has been a total issue of twenty-four thousand copies. The present edition has been entirely rewritten by another author and has been supplied with a fresh set of figures, so that it is practically a new book. The scope remains, however, much as before, and the book will no doubt continue to be widely used as a useful introduction to the study of mineralogy. The general portion, dealing with crystallography and the physical and chemical characters of minerals, occupies 113 pages, and the descriptive portion 196 pages. For each of the more common species described the information is clearly set out under the headings: composition, crystallization, structure, physical characters, varieties, tests, alteration, occurrence, name, use. This is followed by useful lists of minerals arranged according to chemical elements, modes of occurrence, and systems of crystallization; the first of these including notes on economic applications, and the second the elements of petrology. The determinative tables occupy 68 pages, and an appendix gives a summary of the mineral production of the United States for the year 1910. By the incorporation of such practical details the subject is made one of living interest.

Petrographic Methods. The authorized English translation of Part I, Anleitung zum Gebrauch des Polarisationsmikroskops (3rd edit.) *and Part II, Die Gesteinsbildenden Mineralien* (2nd edit.). By ERNST WEINSCHENK, rendered into English by ROBERT W. CLARK. Pp. xvii + 396, with 371 text-figures. (New York and London[1]: McGraw-Hill Book Company, 1912. Price $3.50 = 15*s.* net.)

The German original of this work first appeared in 1901 in two

[1] London agents: Hill Publishing Company, Ltd., 6 and 8 Bouverie Street, Fleet Street, E.C.

separate parts, and the fact that each of these has passed through other editions in German, as well as in Russian, proves that they have found a demand. In the present English edition the two parts are issued together in one volume. The first part deals with the construction and use of the polarizing microscope and its accessories, and explains the phenomena observed in ordinary light and in parallel and convergent polarized light. The second part deals with the preparation of material, methods of investigation, and the description of the various rock-forming minerals. The latter are grouped as opaque, isotropic, uniaxial, and biaxial minerals. Determinative tables extending over 40 pages are bound in the volume, and not loose as in the German edition. The translation has been well done, and the printing and get-up of the book are good. It should find many readers amongst English-speaking students of petrology.

Introduction to the Study of Minerals. A combined text-book and pocket manual. By AUSTIN F. ROGERS. Pp. xx+522, with 591 text-figures. (New York and London: McGraw-Hill Book Company, 1912. Price \$3.50=15*s.* net.)

This book gives a large amount of condensed information extending over a wide range of general mineralogy, and the description of 200 common minerals occupies rather less than half of the volume. There are several novel modes of treatment, especially in the crystallography. The book is well and clearly printed, and with the help of heavy type the facts stand out prominently. It is intended as a text-book for a one-year course in mineralogy, whilst being in a condensed form (and bound in limp leather as a pocket-book) it will be useful for reference in the laboratory and in the field. The high price and the American spellings (which seem to lack a uniformity in treatment) will no doubt tell against the use of the book in this country. Few errors have been noticed, except in the glossary, which requires some revision.

The Examination of Prospects. A Mining Geology. By C. GODFREY GUNTHER. Pp. ix+222, with 79 text-figures. (New York and London: McGraw-Hill Book Company, 1912. Price \$2.00=8*s.* 6*d.* net.)

An account is given of the various forms of ore-deposits and of their occurrence, mainly from the point of view of the mining engineer whose business it is to report on mining properties. Detailed instructions are given as to the methods of sampling the ores in sight and of examining

mines that have been already worked. The examples given and the references quoted are all American. The book is well illustrated by diagrams and sections borrowed from the works of well-known writers on economic geology, and it is issued in a convenient form for carrying in the pocket.

Die Schmuck- und Edelsteine. By Dr. A. Eppler. Pp. x+464, with 223 text-figures and 4 coloured plates. (Stuttgart: Felix Krais, 1912. Price 10.50 Marks, bound in cloth 12 Marks.) Forming Vol. II of 'Gewerbliche Materialkunde', edited by Dr. Paul Krais.

This is essentially a practical book, and is intended for the use of craftsmen. Most books on precious stones have been written by either a pure mineralogist or by a worker in the jewellery trades; but here the author has combined in a particularly happy manner the fundamental ideas of scientific mineralogy with the practical aspect of the question as actually met with in the trade. One half of the volume is devoted to a description of 123 varieties of stones employed for ornamental purposes, these being arranged according to their degree of hardness. This descriptive portion deals more especially with the characters of the materials as concerns the worker, and little is said of modes of occurrence and winning. There is a useful chapter on methods of determination, and determinative tables are also given. Indications of the market values of rough and cut stones are freely quoted. The book is well illustrated, and although some of the figures are rather of the nature of rough sketches, still they are very effective. The four coloured plates representing 169 worked stones, by the three-colour process, are quite attractive. The information given in the text is reliable, and there are only few misprints.

Notes on the Mineralogy of Renfrewshire. By Robt. S. Houston. Pp. 88. (Paisley: Alex. Gardner, 1912. Price 2*s.* 6*d.* net.) Forming Vol. I of the Transactions of the Paisley Naturalists' Society.

This volume on topographical mineralogy is mainly a digest of the published literature relating to the seventy-six species of minerals that have been recorded from Renfrewshire. There are some new records made by the members of the Paisley Naturalists' Society, and several new analyses are given. Instead of giving scrappy reprints from the literature a more useful purpose could have been served by elaborating details of local interest. For instance, the information given respecting the typically Renfrewshire mineral greenockite is confined to a brief (and

naccurate) extract from the original note of 1840. Surely the Paisley Naturalists are in a position to tell us something of interest about the occurrence of this mineral, exactly when and where it was found, and whether specimens may be now collected. The book is full of a tiresome repetition of such signs as 'C. of W. S. F.', 'N. S. A. of S. R.', &c.; and here, as in other points, the volume might have been much improved by editing. Dana's numbers for species (as used in the sixth edition of the 'System') are quoted as if they were regarded as constants.

Traité de Technique Minéralogique et Pétrographique. 2me partie, tom. I, *Les méthodes chimiques qualitatives.* By Louis Duparc and Alfred Monnier. Pp. xi+372, with 117 text-figures and 1 coloured plate. (Leipzig: Veit & Co., 1913 [i.e. 1912]. Price 15 Marks.)

The first part of this work by Professor Duparc and his assistant, the late Dr. Francis Pearce, was devoted to optical methods; it appeared so long ago as 1907 and has been much appreciated. The present part deals with the qualitative analysis of minerals and rocks, a branch of the subject on which Professor Duparc is well qualified to write with authority, for not only is he professor of mineralogy and petrology but also director of the laboratories of analytical chemistry in the university of Geneva. A second volume on quantitative analysis is promised.

In the present volume there are separate chapters on microchemical reactions, blowpipe tests, spectroscopic analysis (with the usual coloured plate of flame spectra), and the wet analysis of inorganic substances. All this is on much the same lines as in the ordinary textbooks on analytical chemistry. In addition, we have a chapter on the separation and purification of minerals for analysis, and a short chapter on the detection of radioactivity. Finally, there are tables for the determination of minerals (77 pp.), which are based on the well-known tables of Kobell.

The Mineral Kingdom. By Dr. R. Brauns. Translated, with additions, by L. J. Spencer. 4to, parts 17 to 25, pp. 297–432, with 57 text-figures and 41 plates. (Esslingen a. N.: J. F. Schreiber; London: Williams & Norgate, 1912. Price 2*s.* each part; complete in half-leather £2 16*s.*)

The last nine parts of this book fully maintain the standard attained by the preceding sixteen, which were reviewed in the last number of this Magazine.

Sixty pages are devoted to the more important rock-forming minerals and allied silicates. Under the several species such details of the

optical characters are given as will assist in their recognition in thin sections of rocks. The three plates of photomicrographs illustrating this part are most beautiful reproductions. A very-well-written chapter is one dealing with nephrite and jadeite, and their occurrence.

Under the 'mineral salts' is found an excellent description of the minerals of the German salt-deposits. Special prominence is given to the methods of mining these minerals and to their technical applications, which is the more welcome by reason of the frequent absence from mineralogical works of details of this kind. Amber is similarly treated, all the trade varieties being defined. The book closes with an appendix on 'The formation of a collection of minerals'; this is full of hints which all collectors will find useful.

An exhaustive index, carefully compiled, converts the whole work into a handy book of reference which, for general information, is probably unequalled among mineralogical works.

W. C. S.